

Observing and modeling biodiversity

Ryan Pavlick, JPL/Caltech

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Hyspiri Science and Applications Workshop

**Earth system models need
more functional diversity.**

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more functional diversity.**

**Ecological theory can get us part
of the way there.**

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**Spaceborne imaging spectroscopy
can take us the rest of the way.**

Real World



350,000+ plant species

Immense functional diversity

Adaptive

Real World

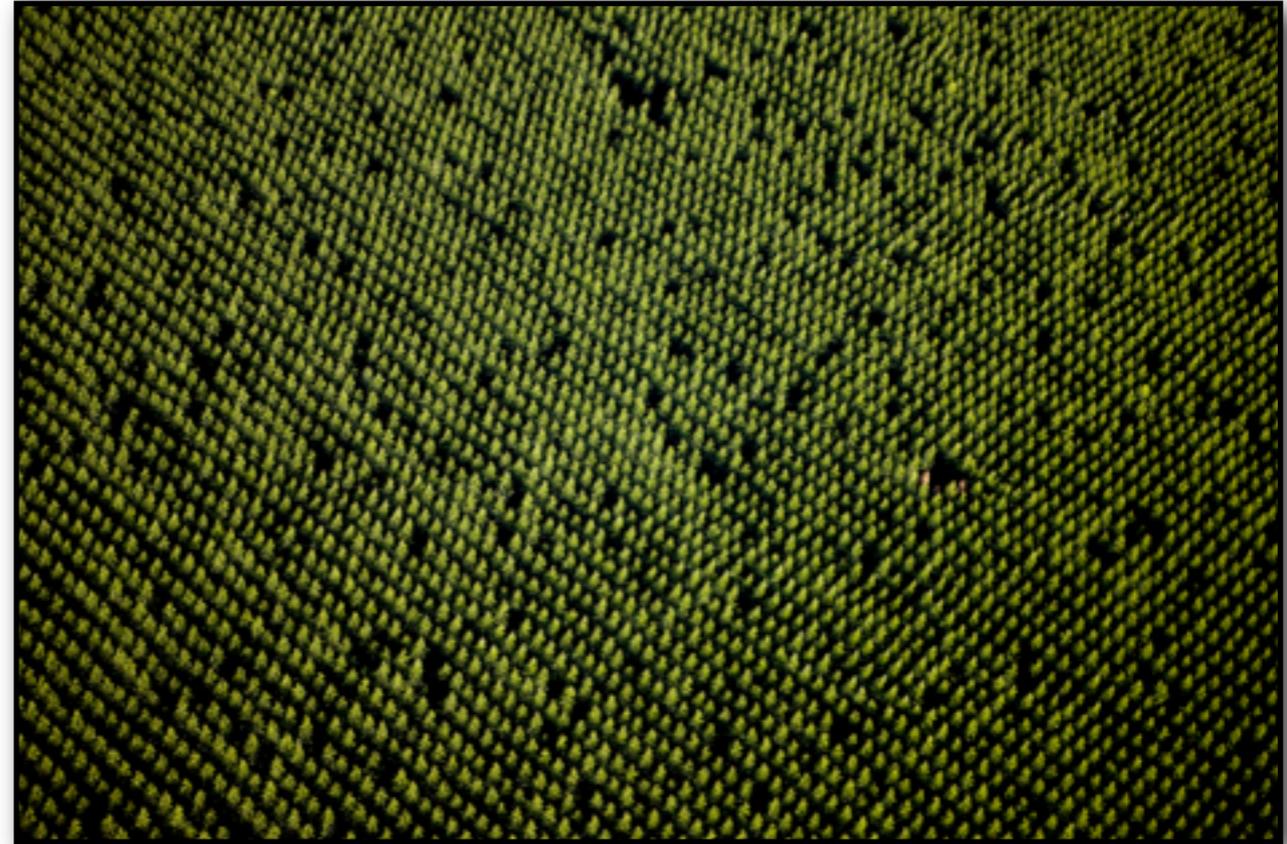


350,000+ plant species

Immense functional diversity

Adaptive

Current modeling paradigm



Abstracted to ~10
Plant Functional Types (PFTs)

Relatively sparse

Static

Experimental and theoretical ecology



Source: bgc-jena.mpg.de

Diversity enhances productivity,
lowers temporal variability,
increases ecosystem resilience
to change

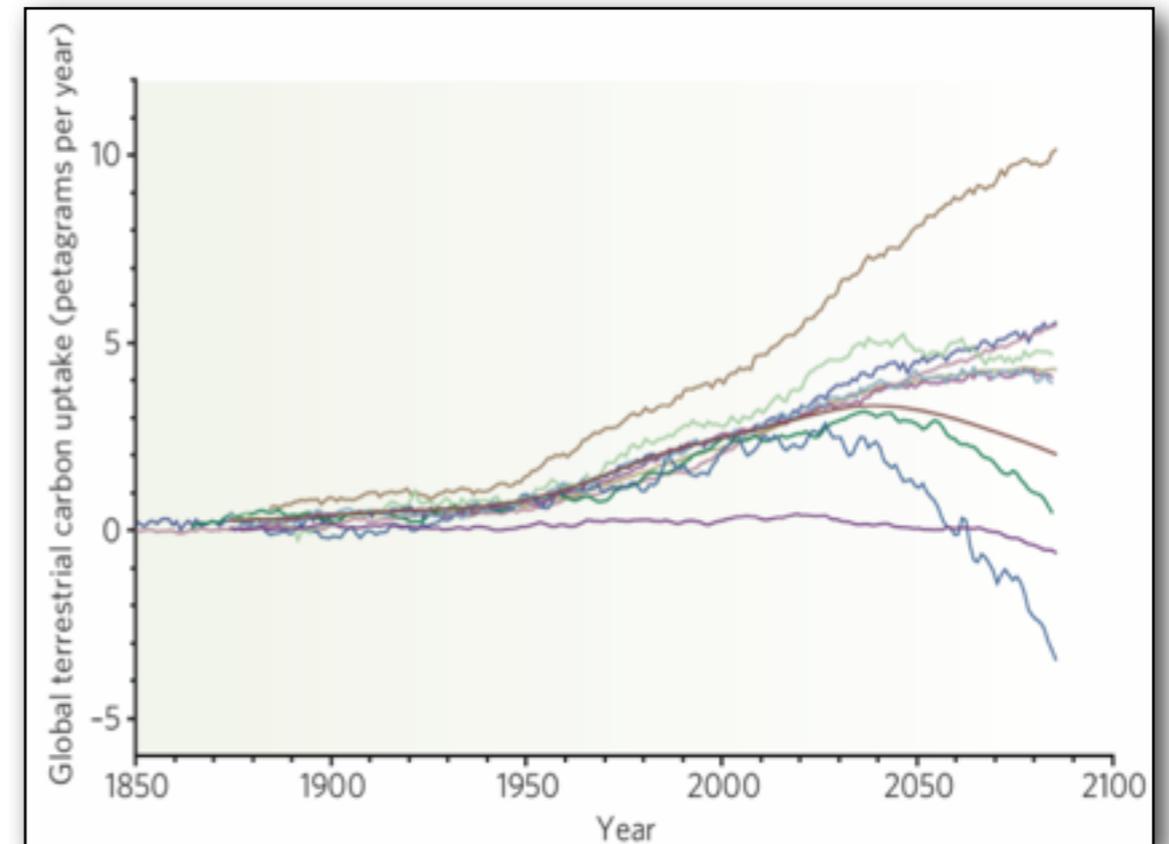
Experimental and theoretical ecology



Source: bgc-jena.mpg.de

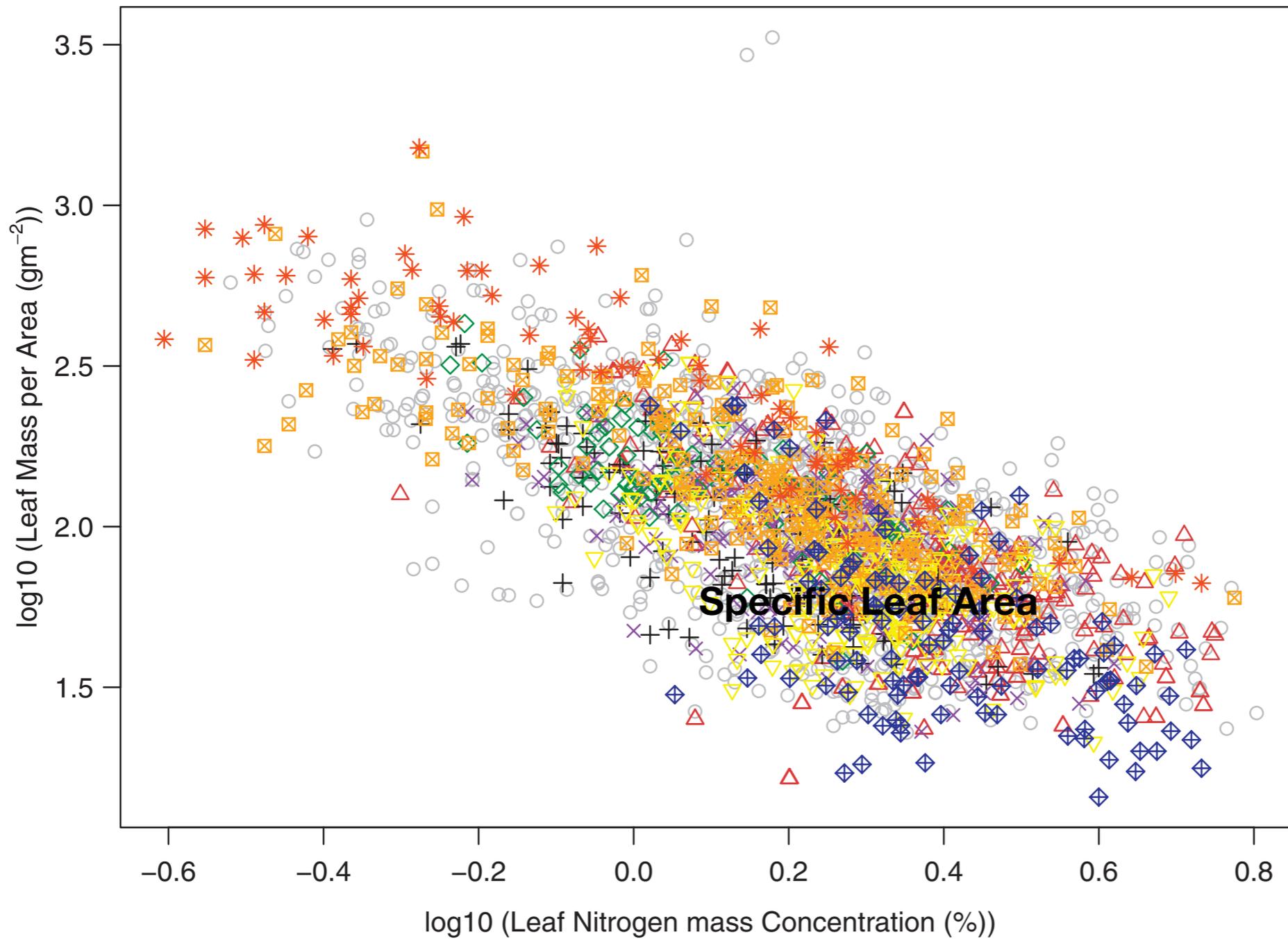
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Current global models



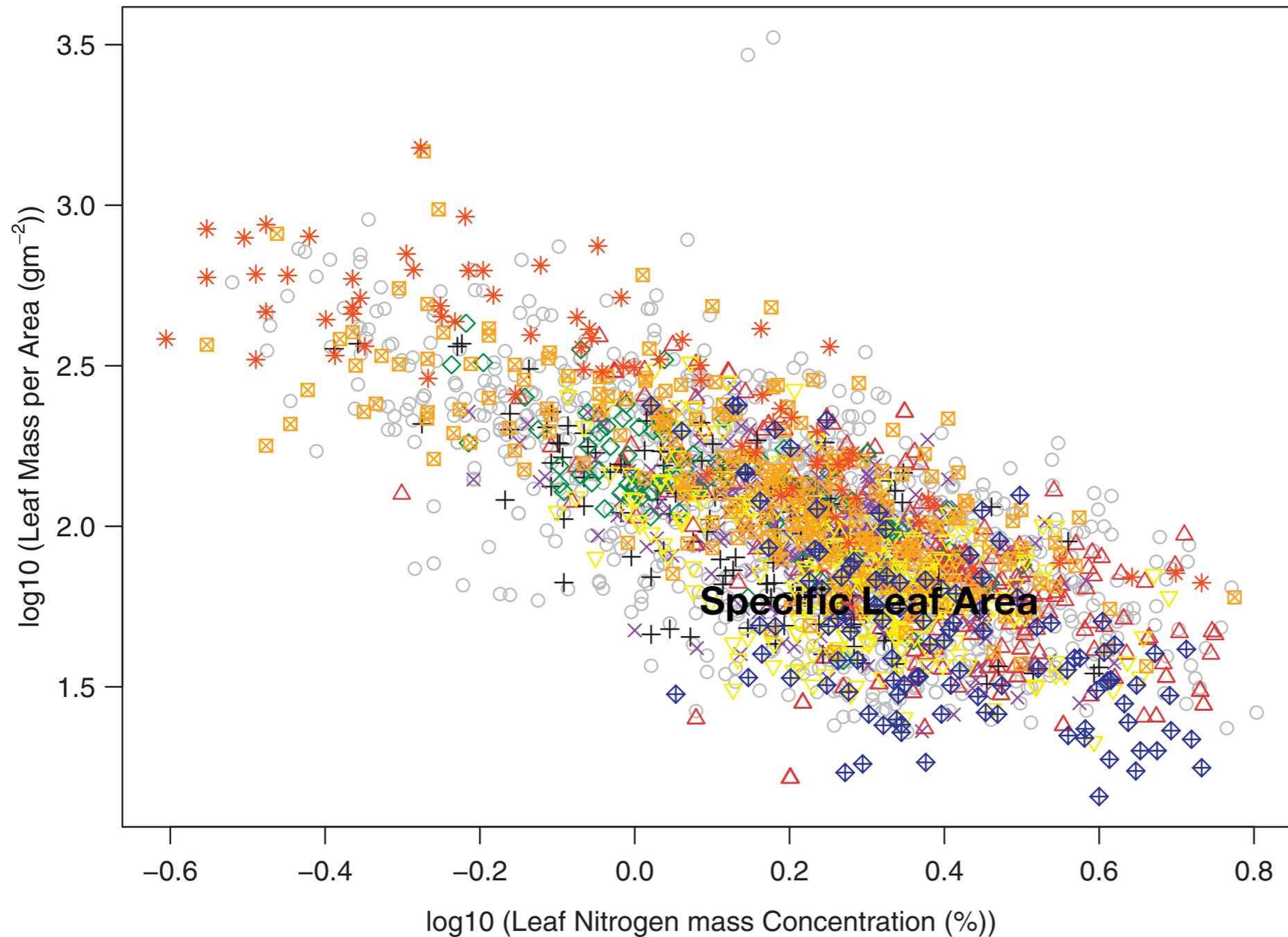
Source: Heimann and Reichstein 2008, Friedlingstein et al. 2006

Some PFT-based models
predict catastrophic positive
feedbacks, e.g. Amazon
dieback (Cox et al. 2000)



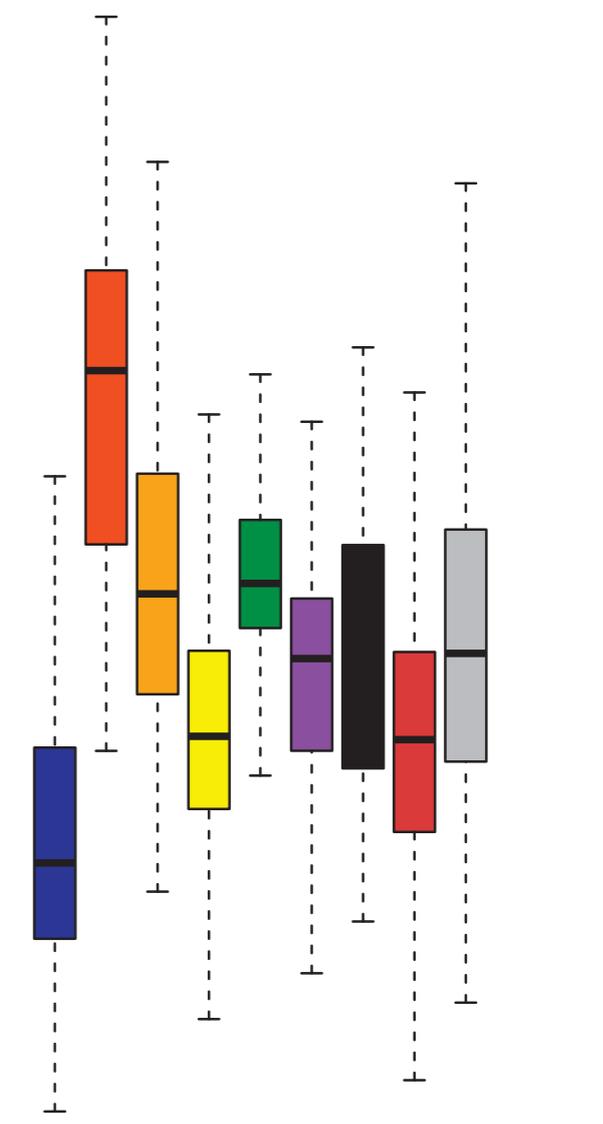
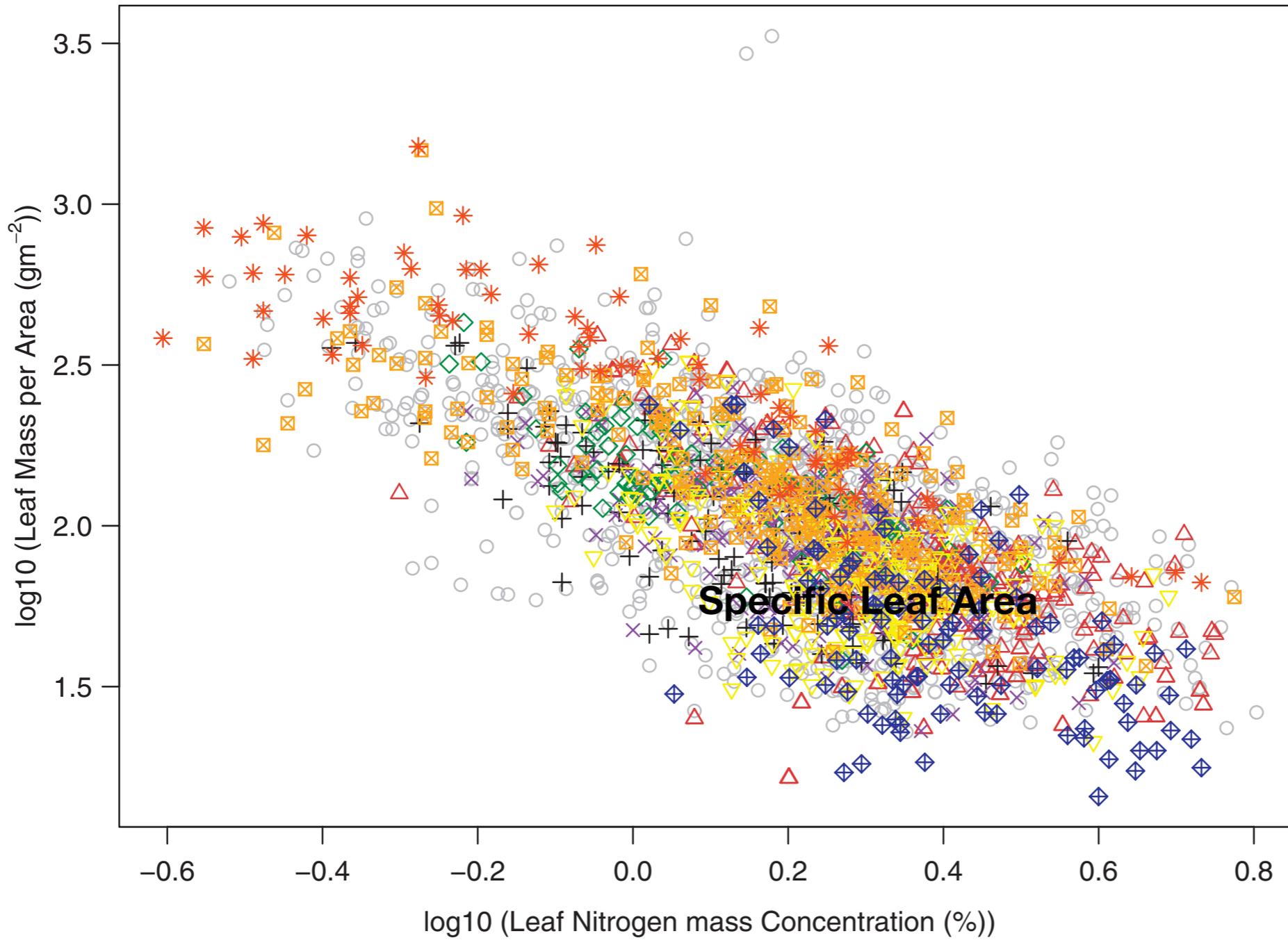
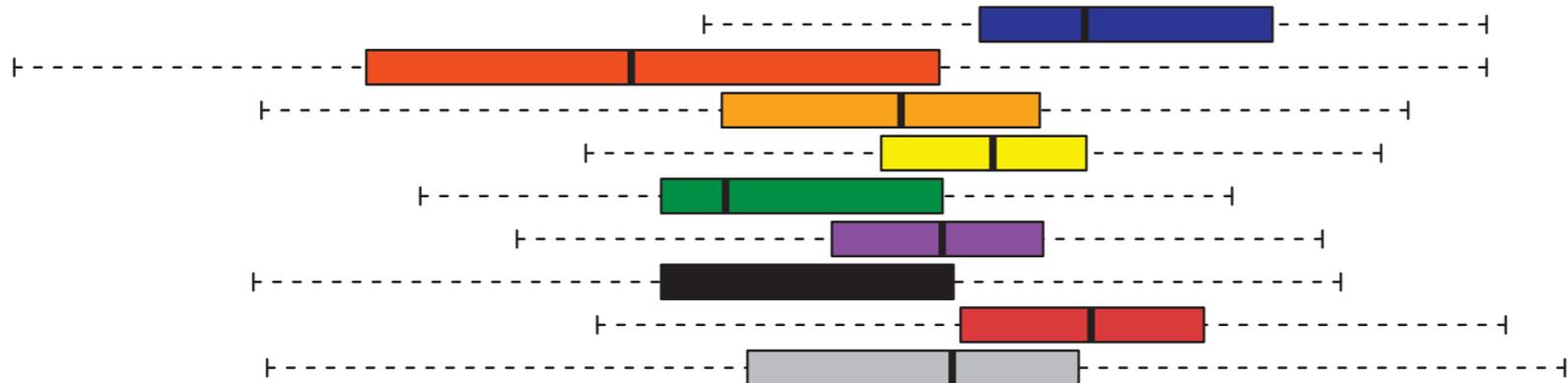
PFTs

- ◆ BOREAL FOREST
- * DESERT
- ⊠ SAVANNA
- ▽ TEMPERATE FOREST
- ◇ TEMPERATE WET FOREST
- × TROPICAL DRY FOREST
- + TROPICAL WET FOREST
- △ TUNDRA
- WOODLAND/GRASSLAND



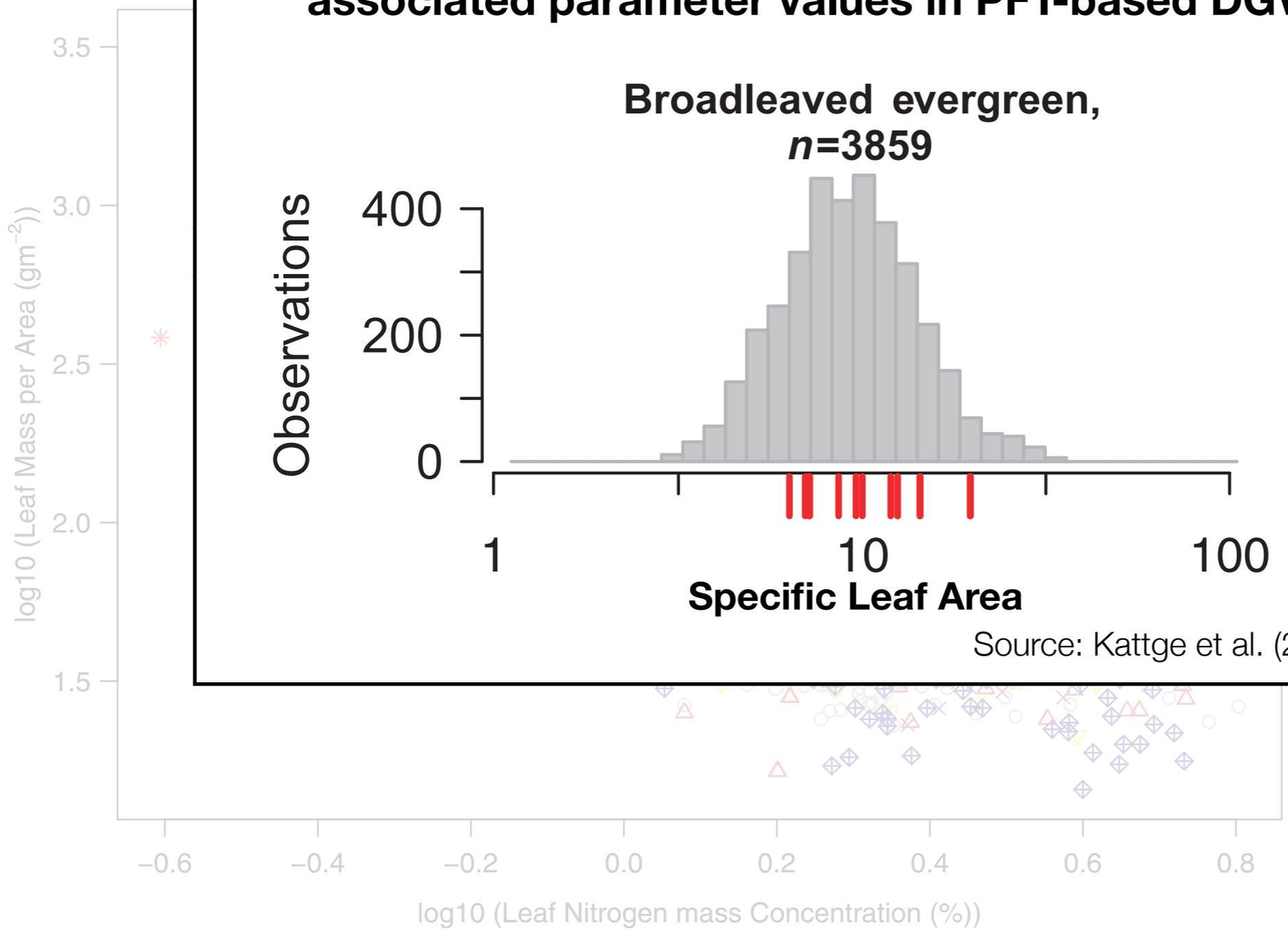
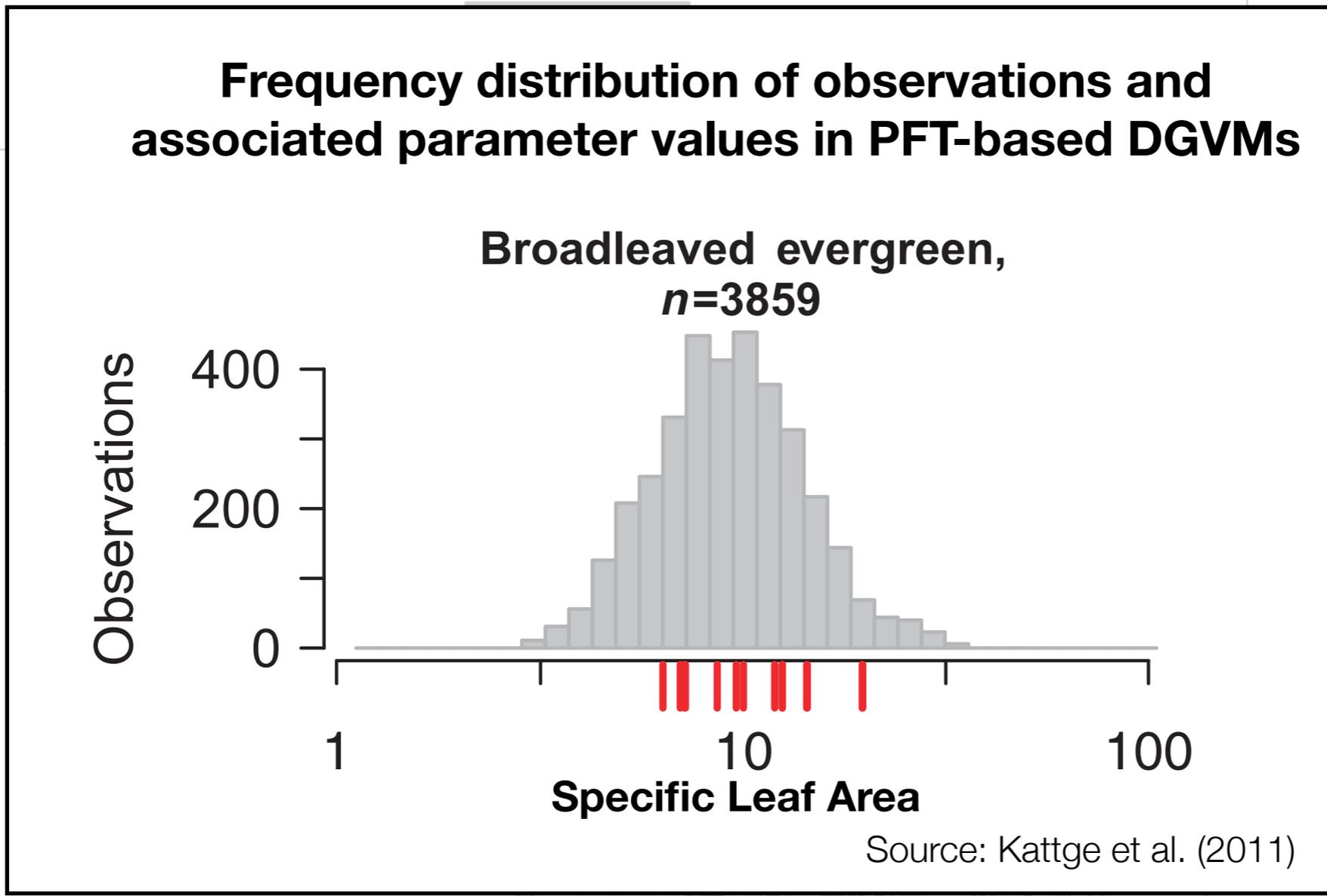
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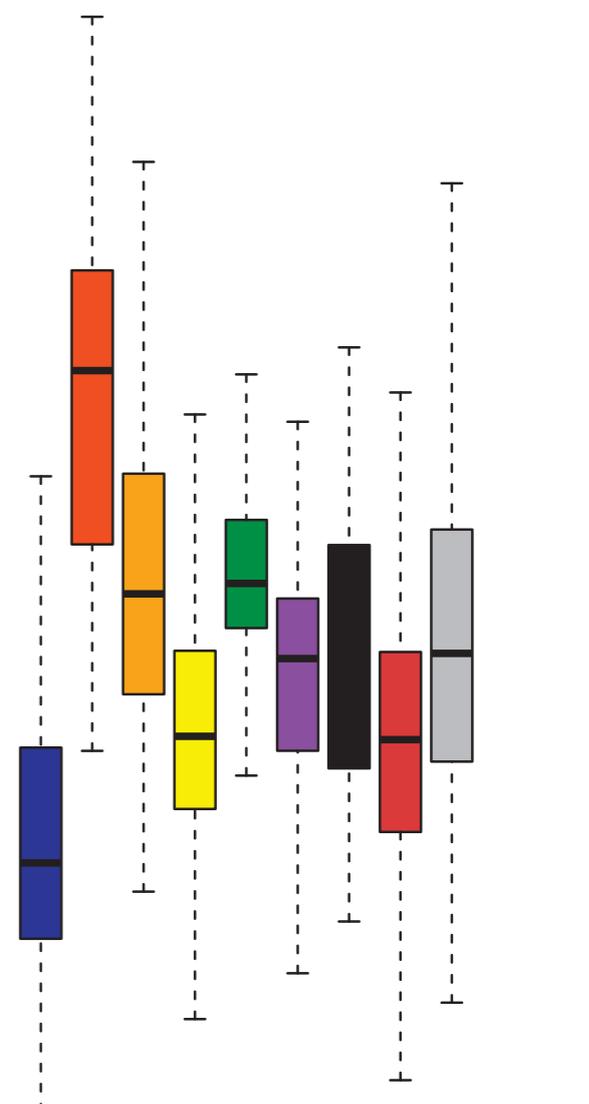
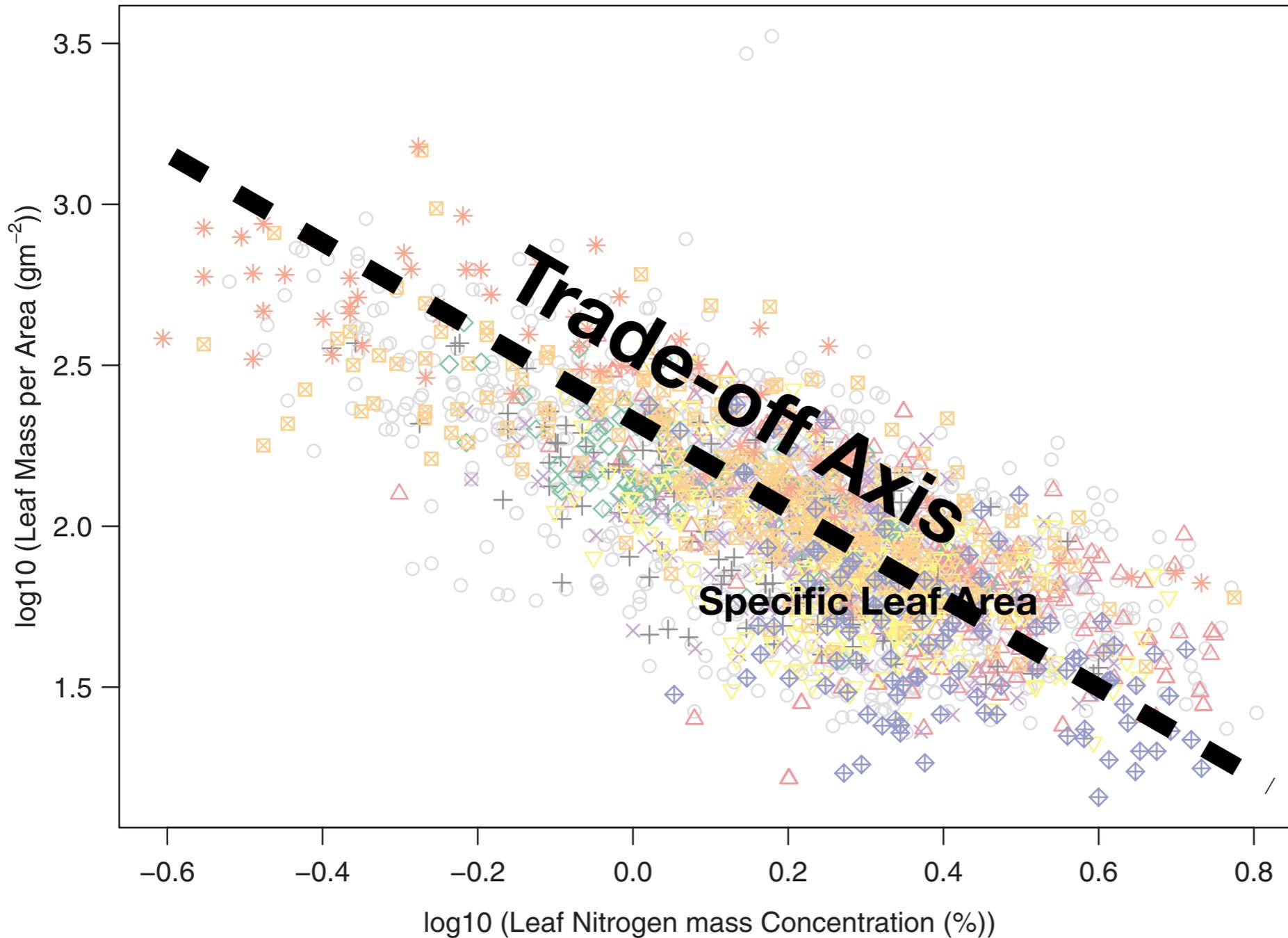
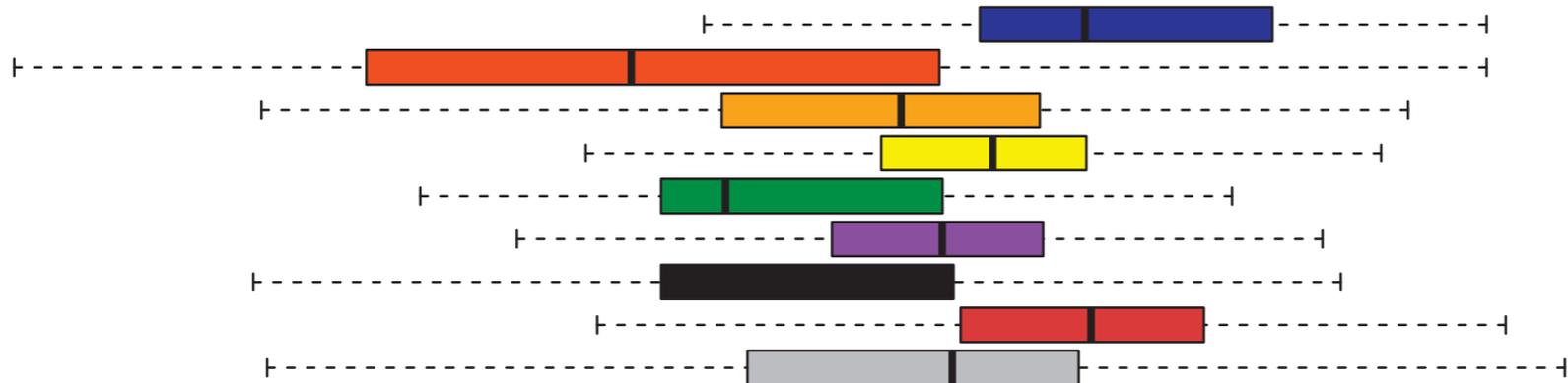
PFTs

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- ◇ TEMPERATE WET FOREST
- × TROPICAL DRY FOREST
- ◇ TROPICAL WET FOREST
- ◇ NDRA
- ◇ WOODLAND/GRASSLAND



PFTs

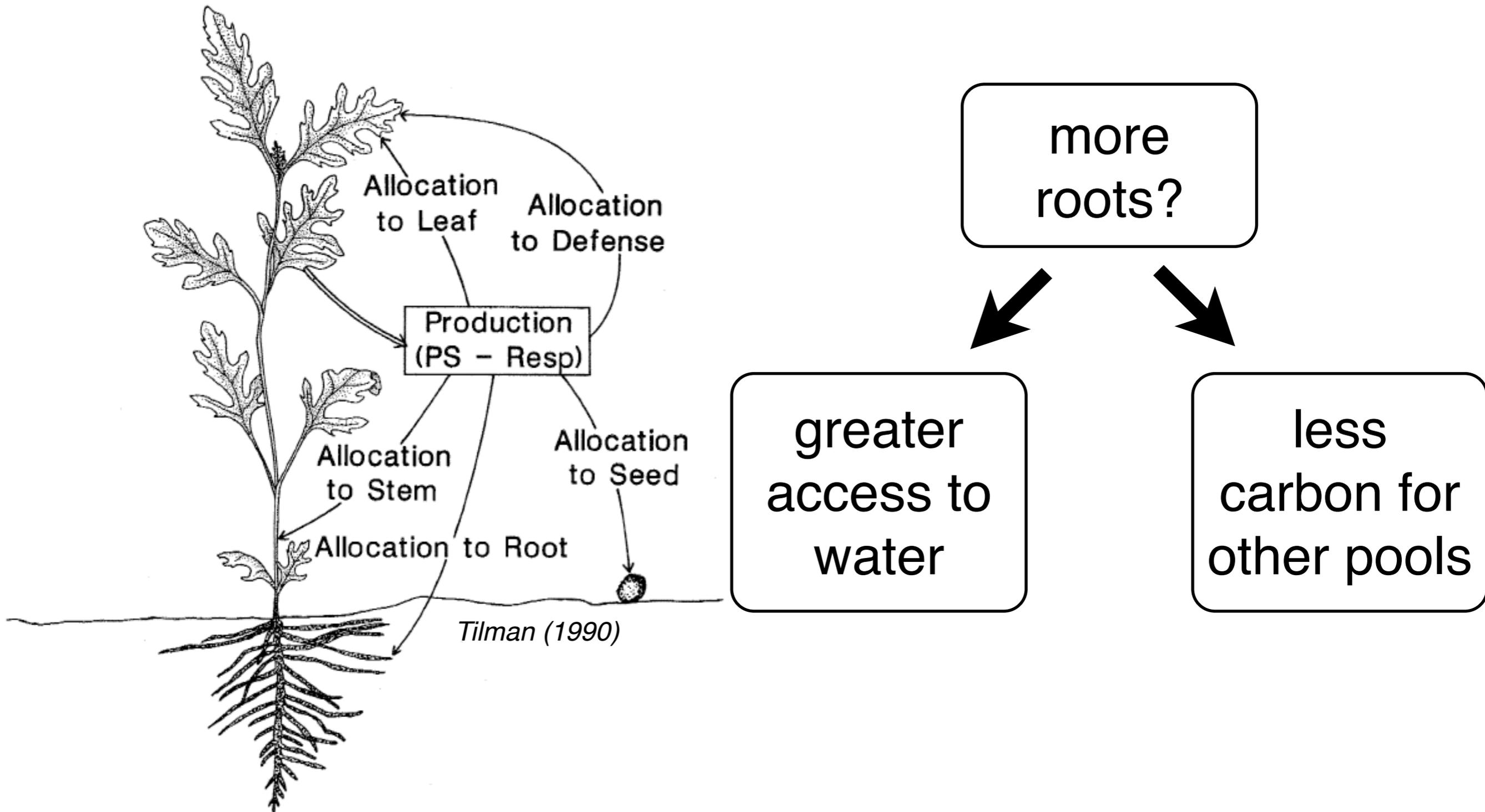
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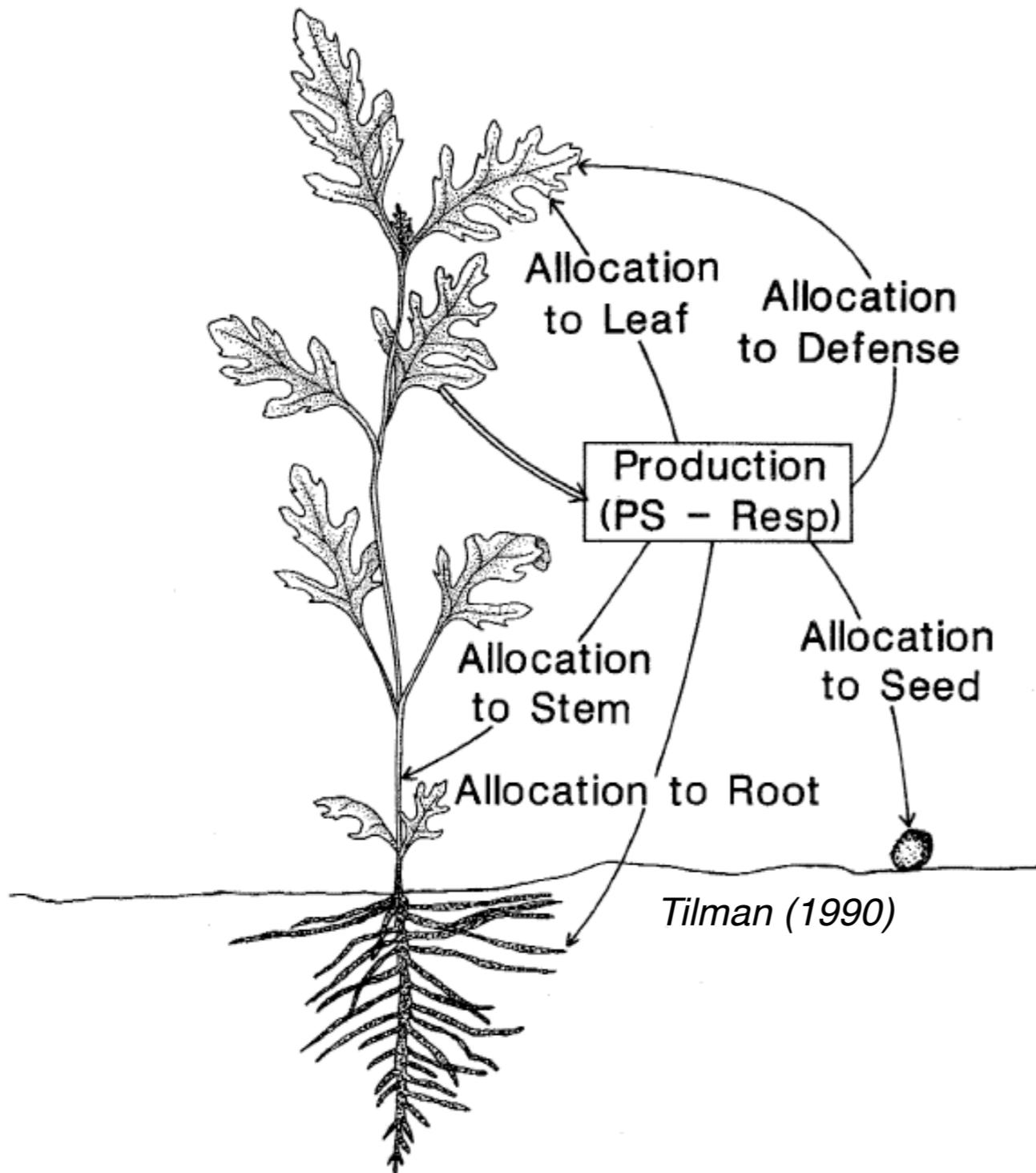
**Earth system models need
more functional diversity.**

**Ecological theory can get us part
of the way there.**

Functional tradeoffs



Functional tradeoffs



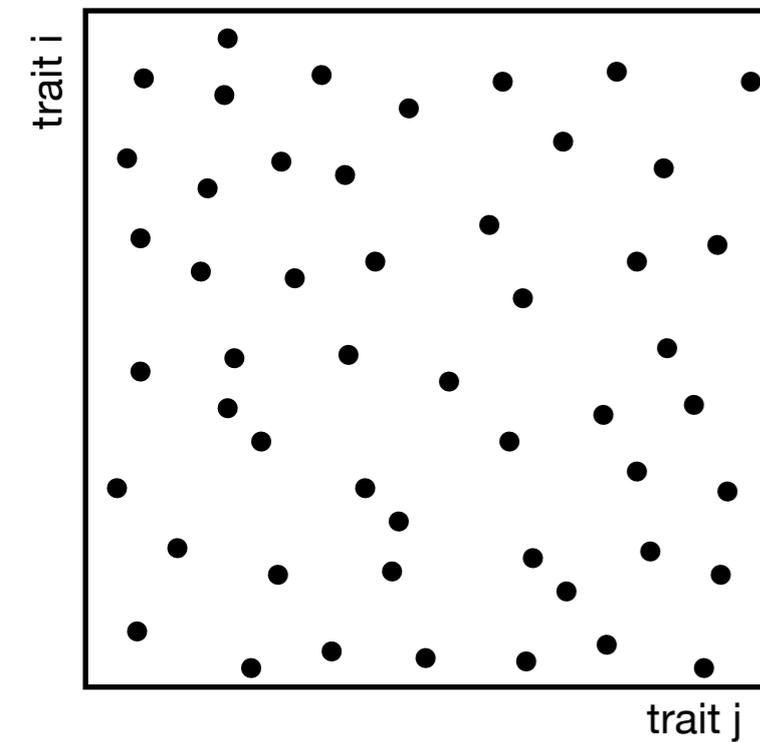
more leaf
nitrogen?



potentially more
photosynthesis

more
respiration

Jena Diversity (JeDi) DGVM

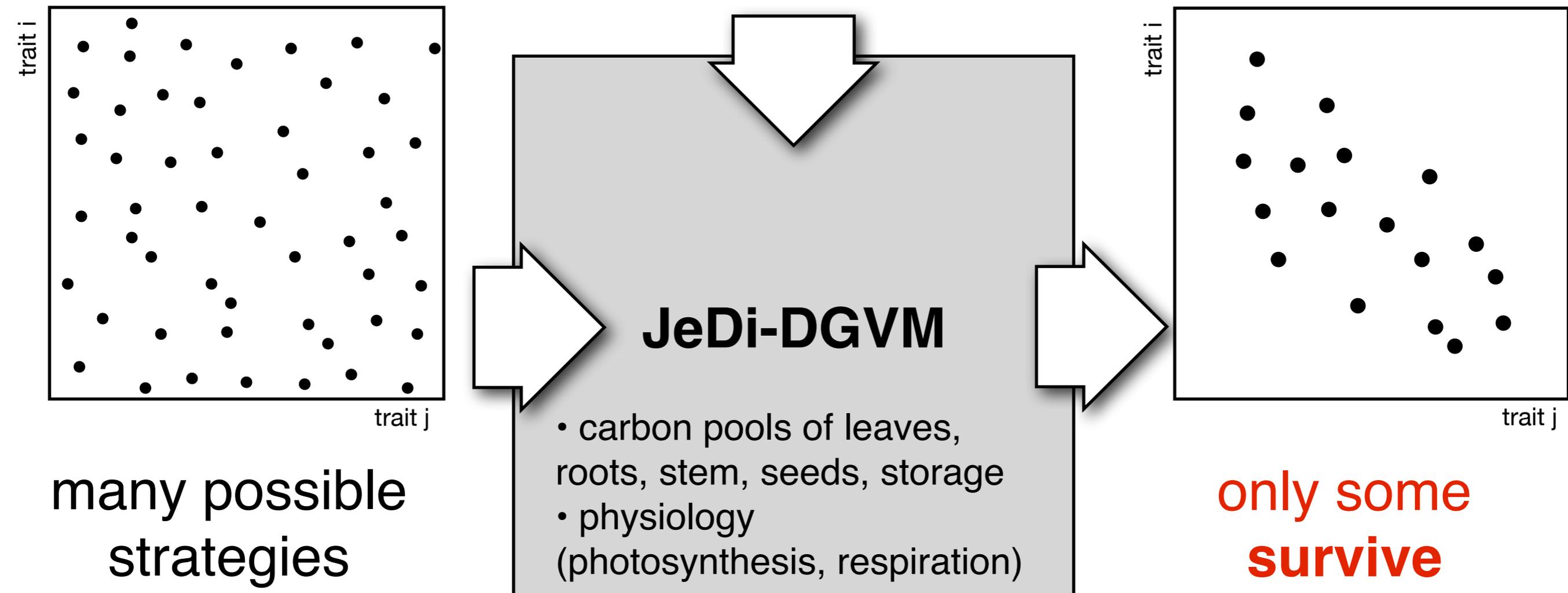


**many possible
strategies**

- relative allocation
- phenology
- plant physiology

Jena Diversity (JeDi) DGVM

environment constrains production
(light, water, temperature)

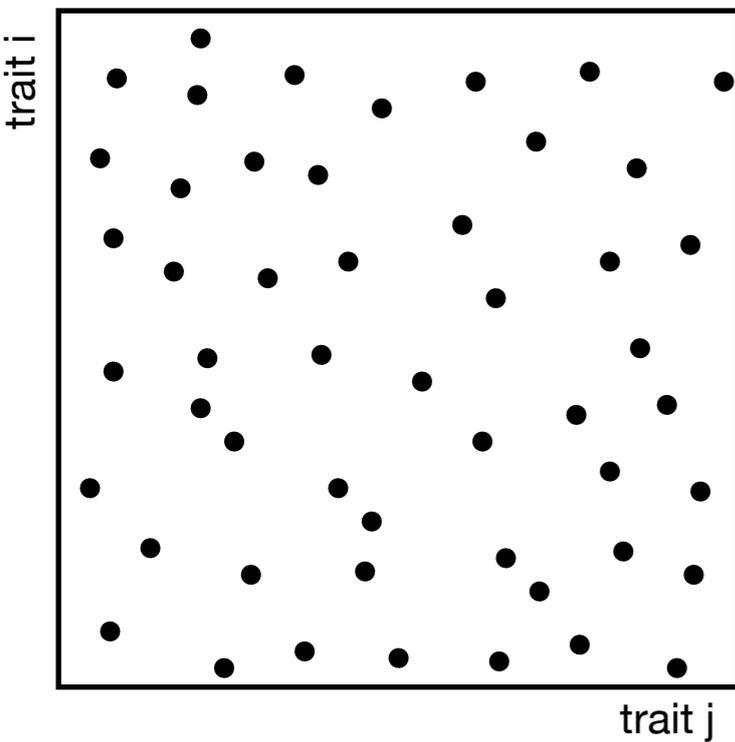


- relative allocation
- phenology
- plant physiology

- **survival**
- biomass
- fluxes

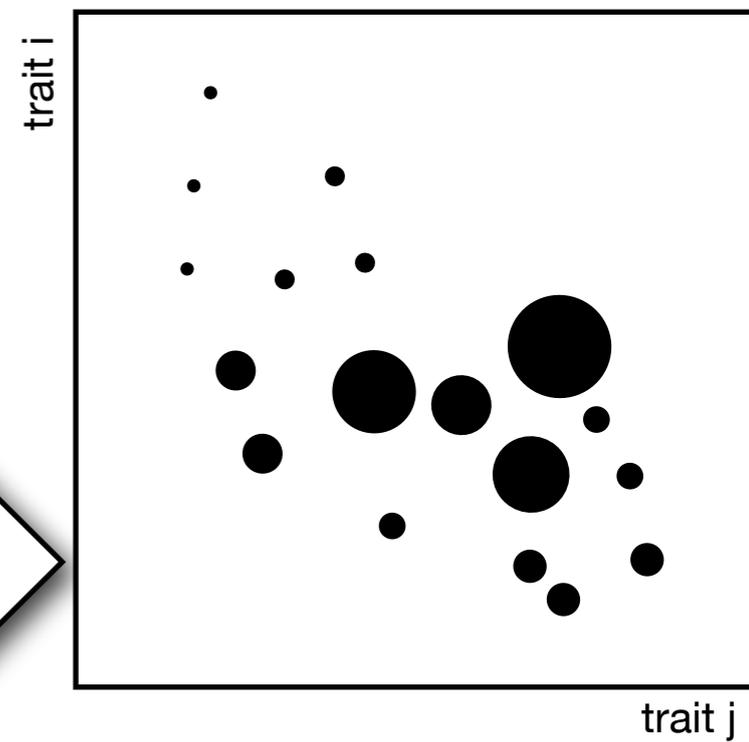
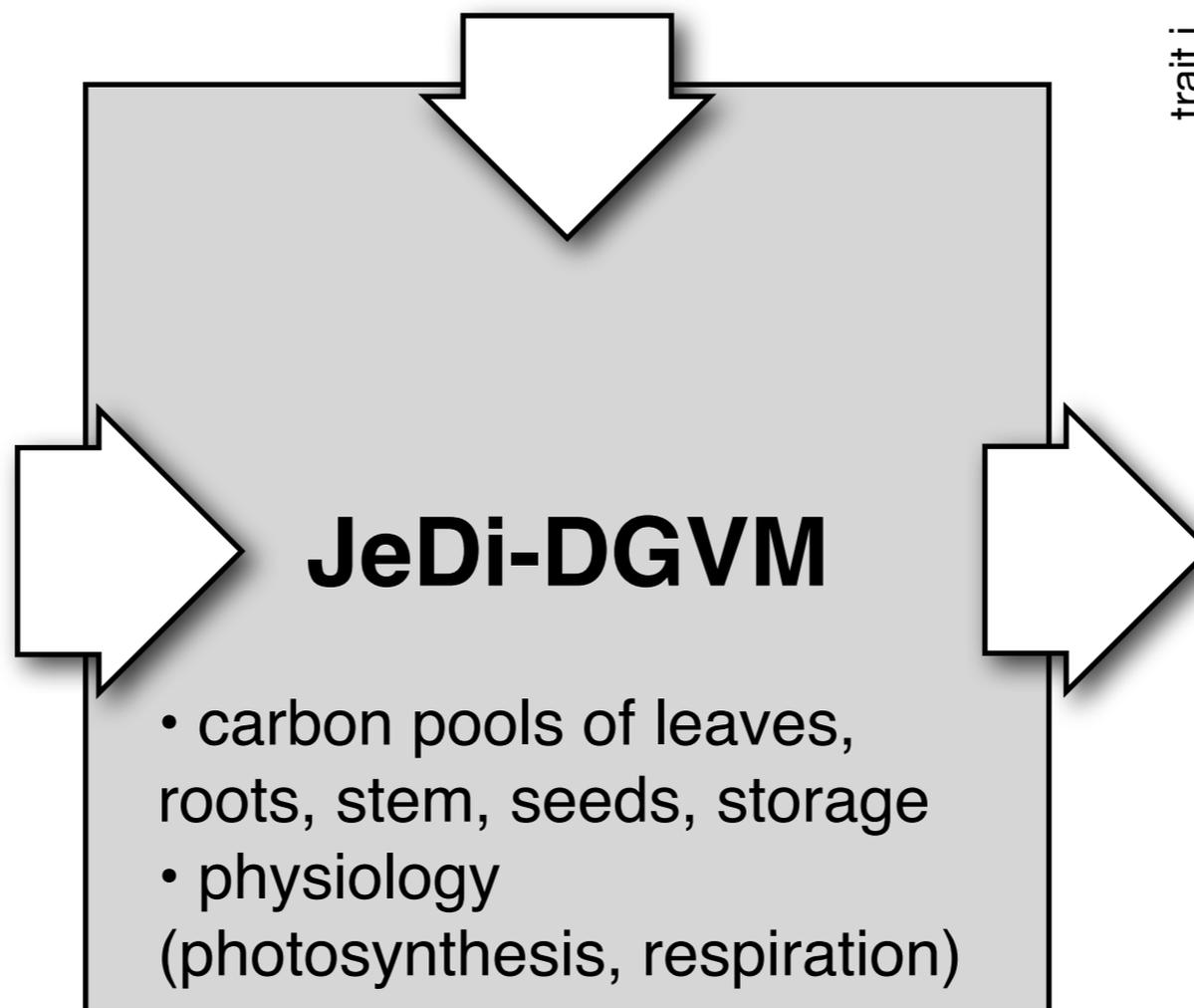
Jena Diversity (JeDi) DGVM

environment constrains production
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many possible strategies

- relative allocation
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- plant physiology

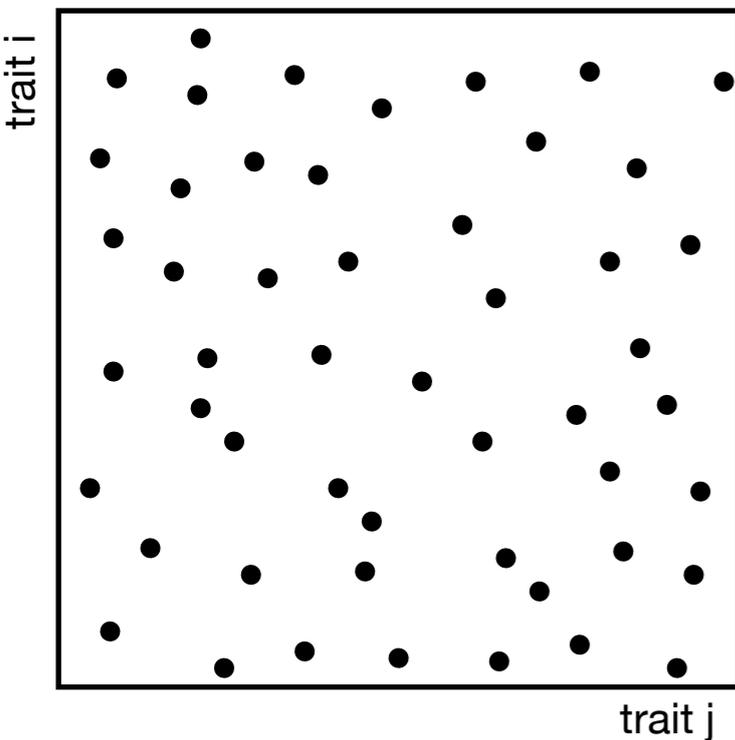


even fewer dominate

- survival
- **biomass**
- fluxes

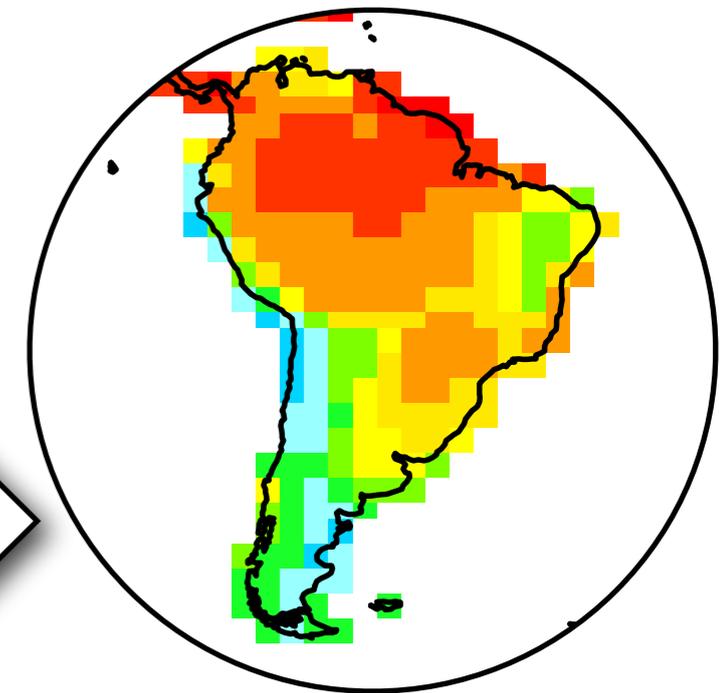
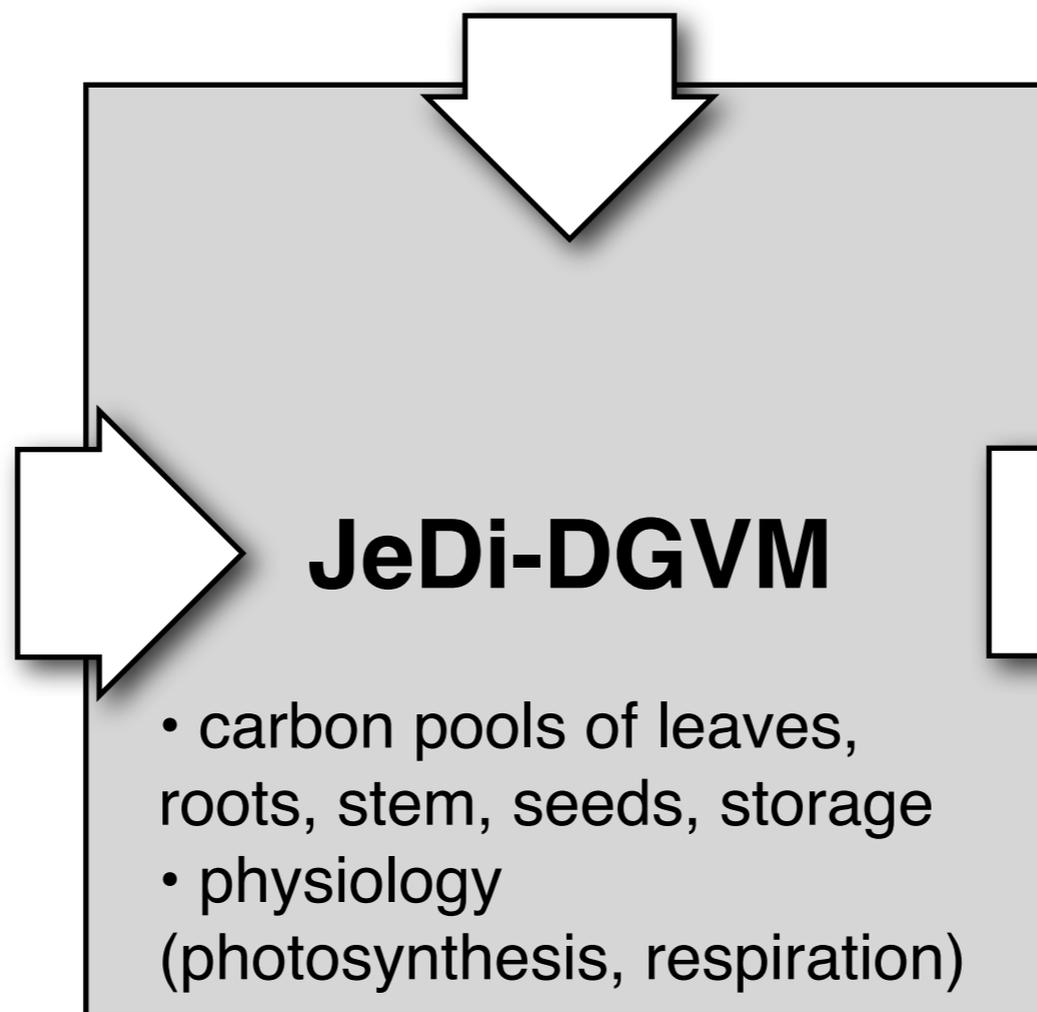
Jena Diversity (JeDi) DGVM

environment constrains production
(light, water, temperature)



many possible strategies

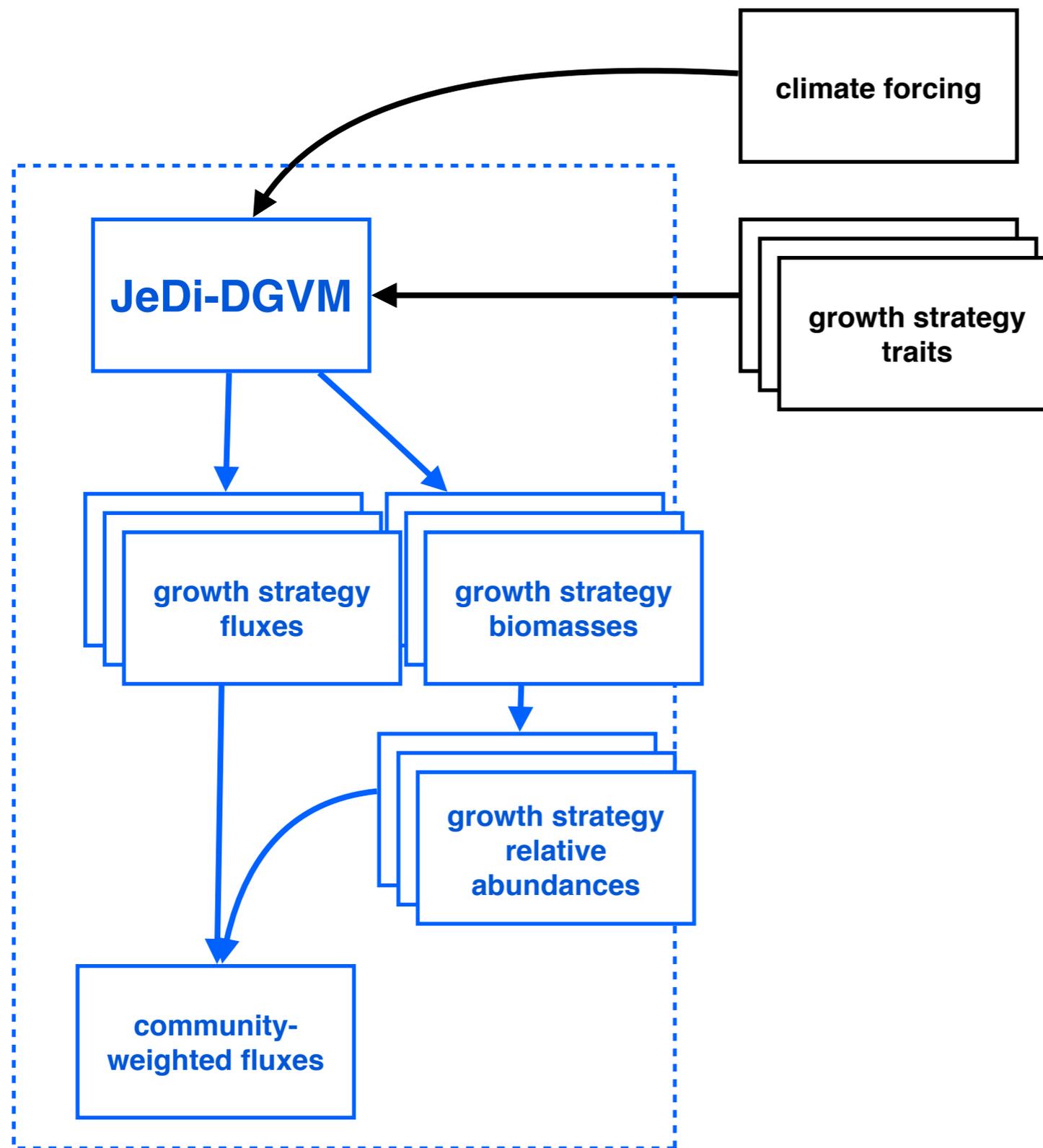
- relative allocation
- phenology
- plant physiology



weight fluxes by biomass to get to ecosystem scale

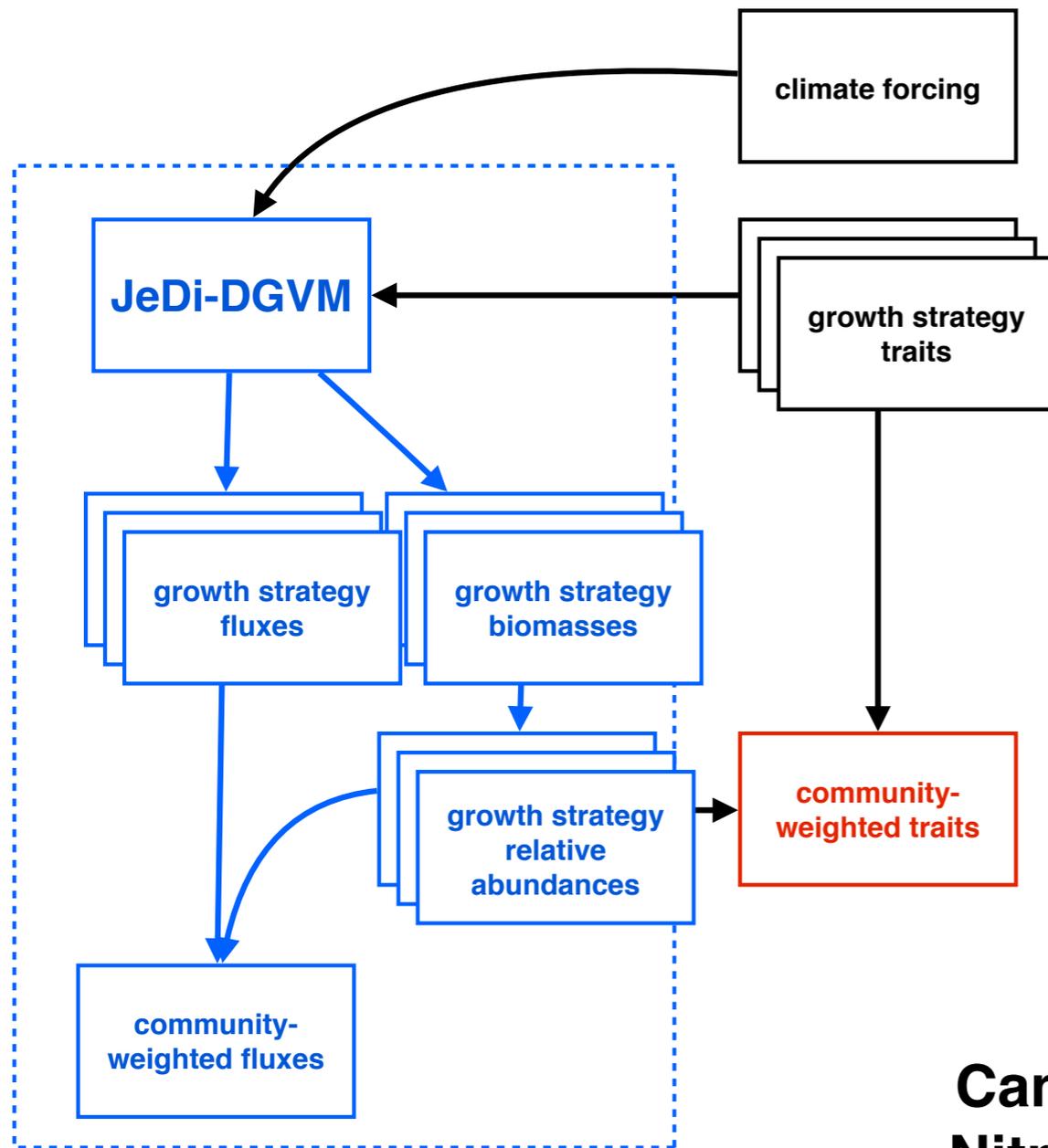
- survival
- biomass
- **fluxes**

Comparing diverse and PFT-like approaches



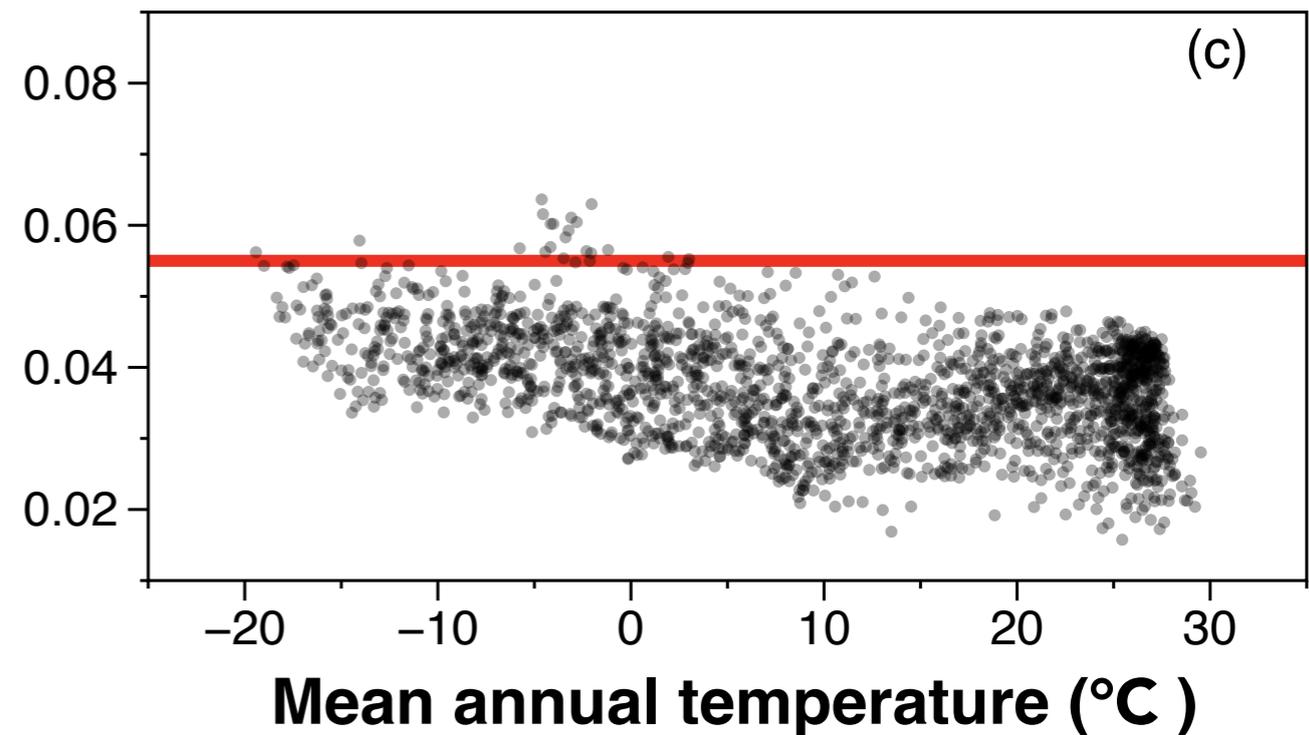
Diverse approach

Community-weighted traits

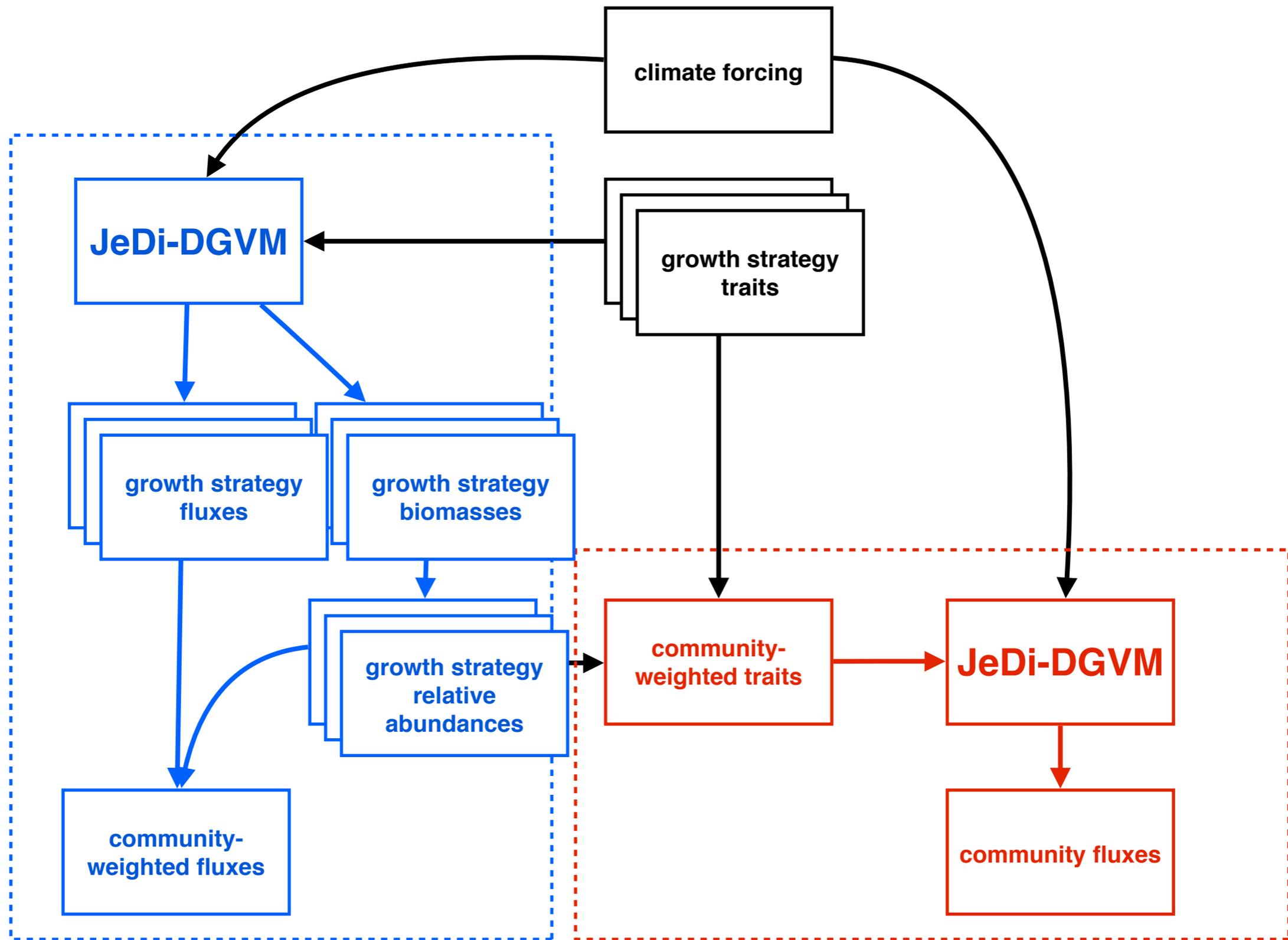


Diverse approach

**Canopy
Nitrogen
(gN/gC)**



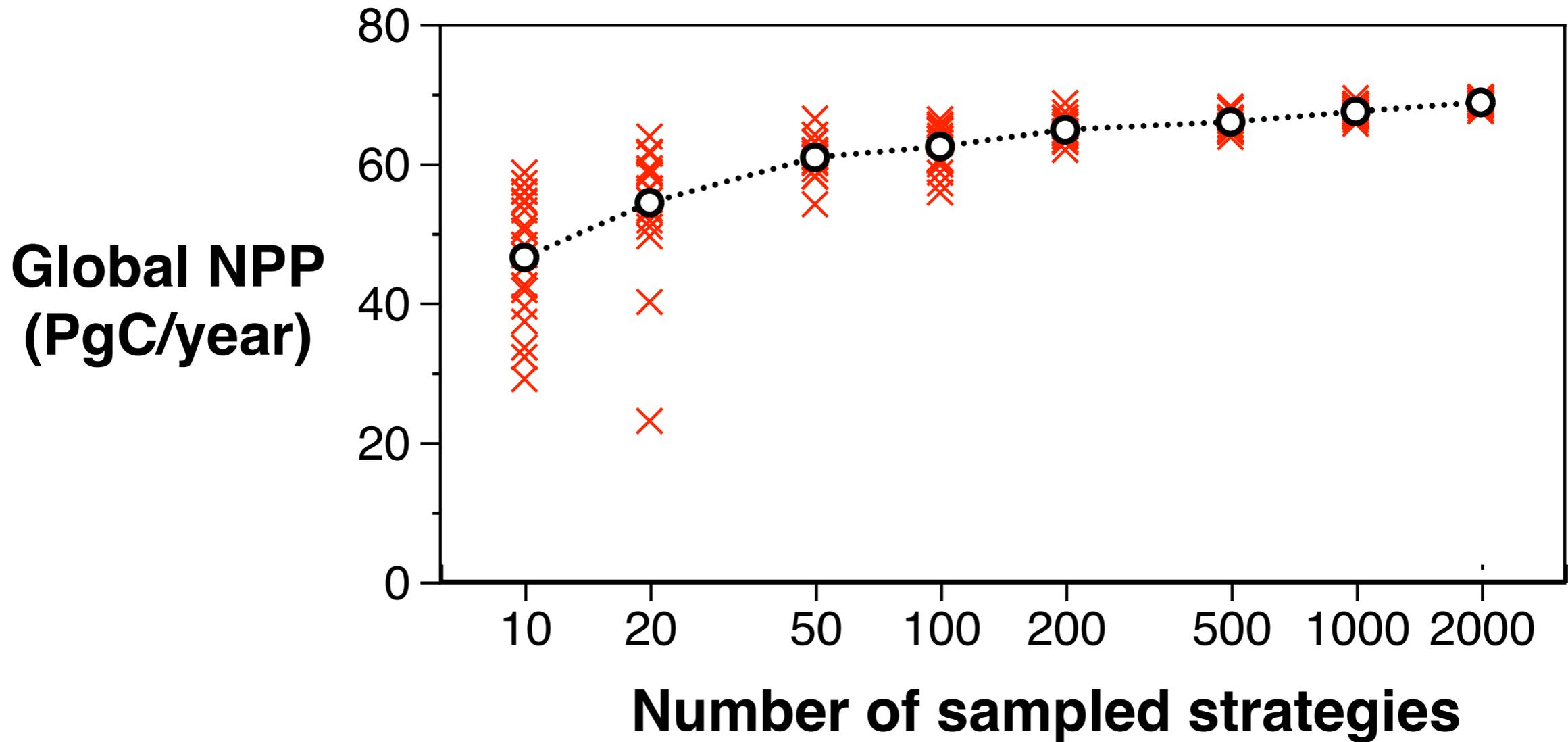
Comparing diverse and PFT-like approaches



Diverse approach

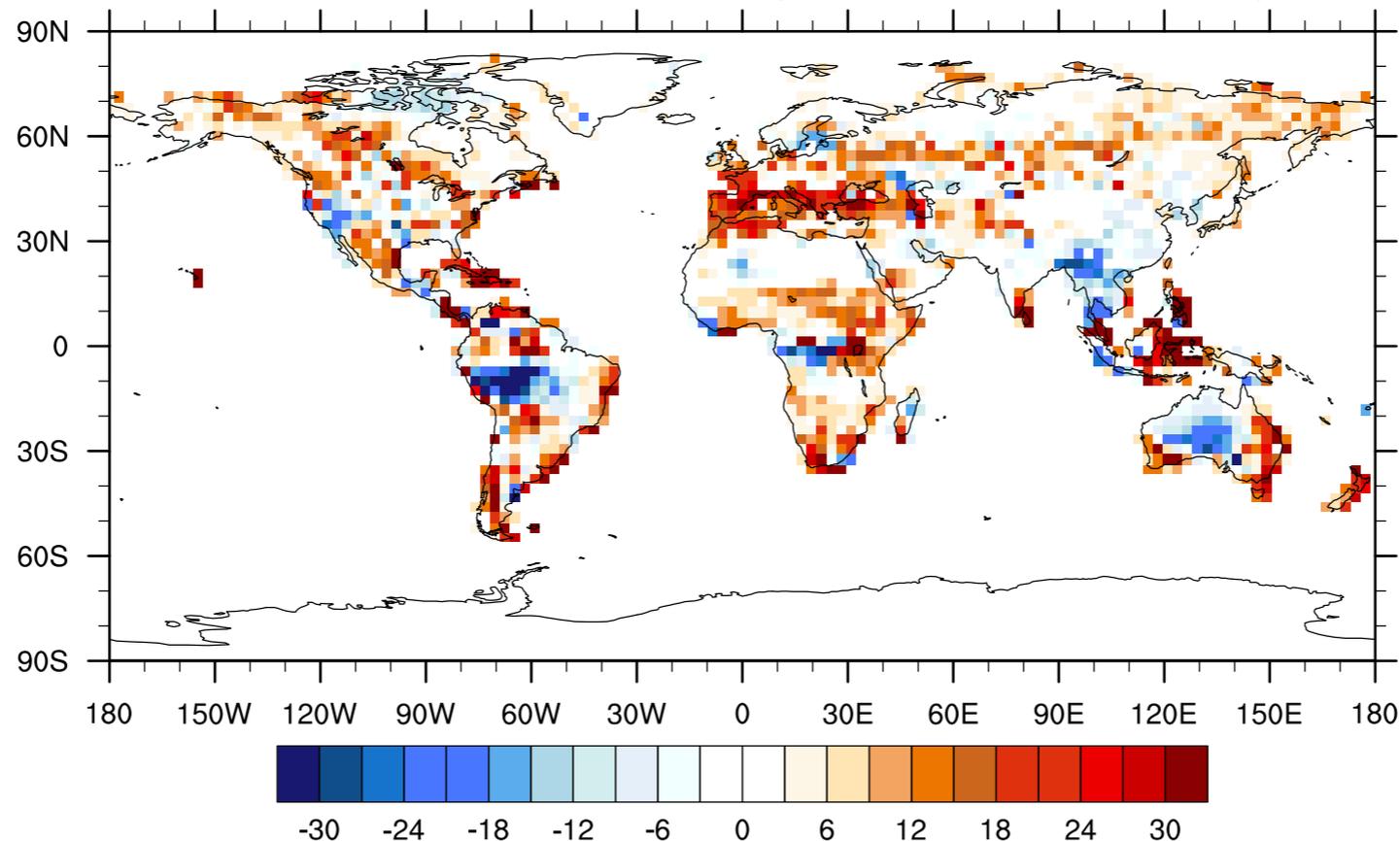
PFT-like approach

Diversity = Higher productivity



Diverse approach = Lower temporal variability

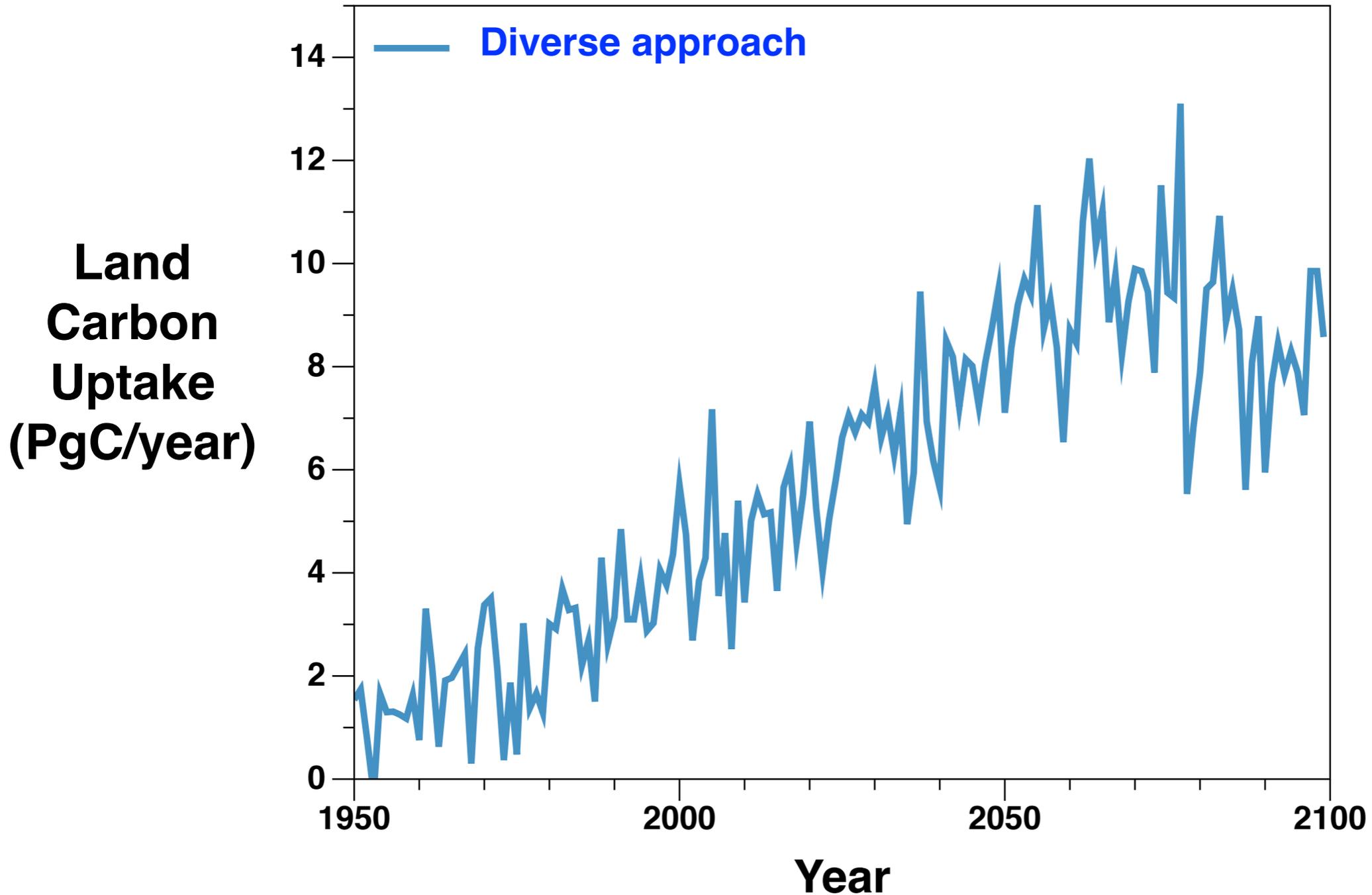
Relative % difference in **intraannual evapotranspiration** variability



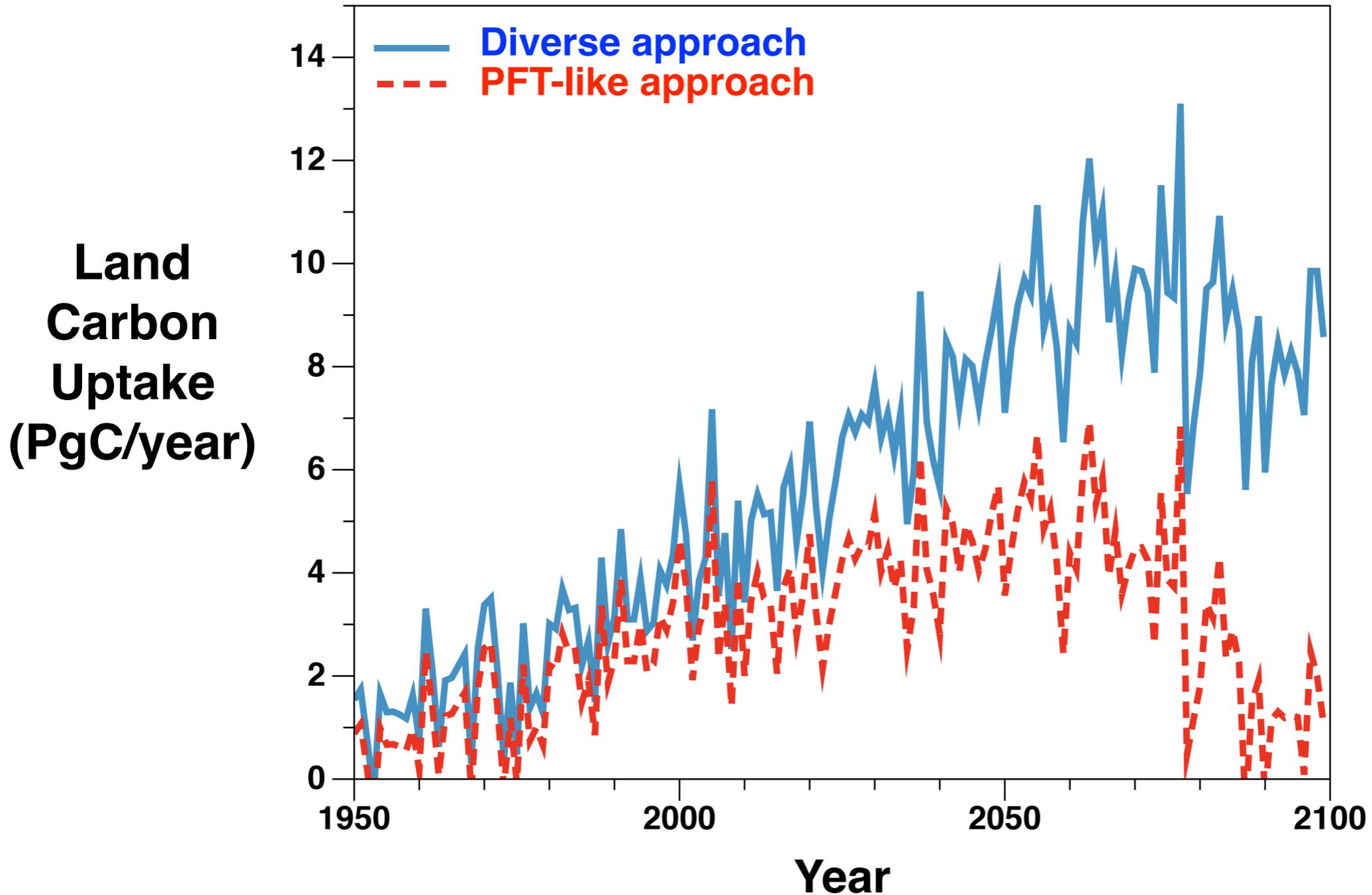
Mathematically inevitable
due to averaging and
negative covariance effects.

In agreement with field/lab
experiments and previous
theoretical models.

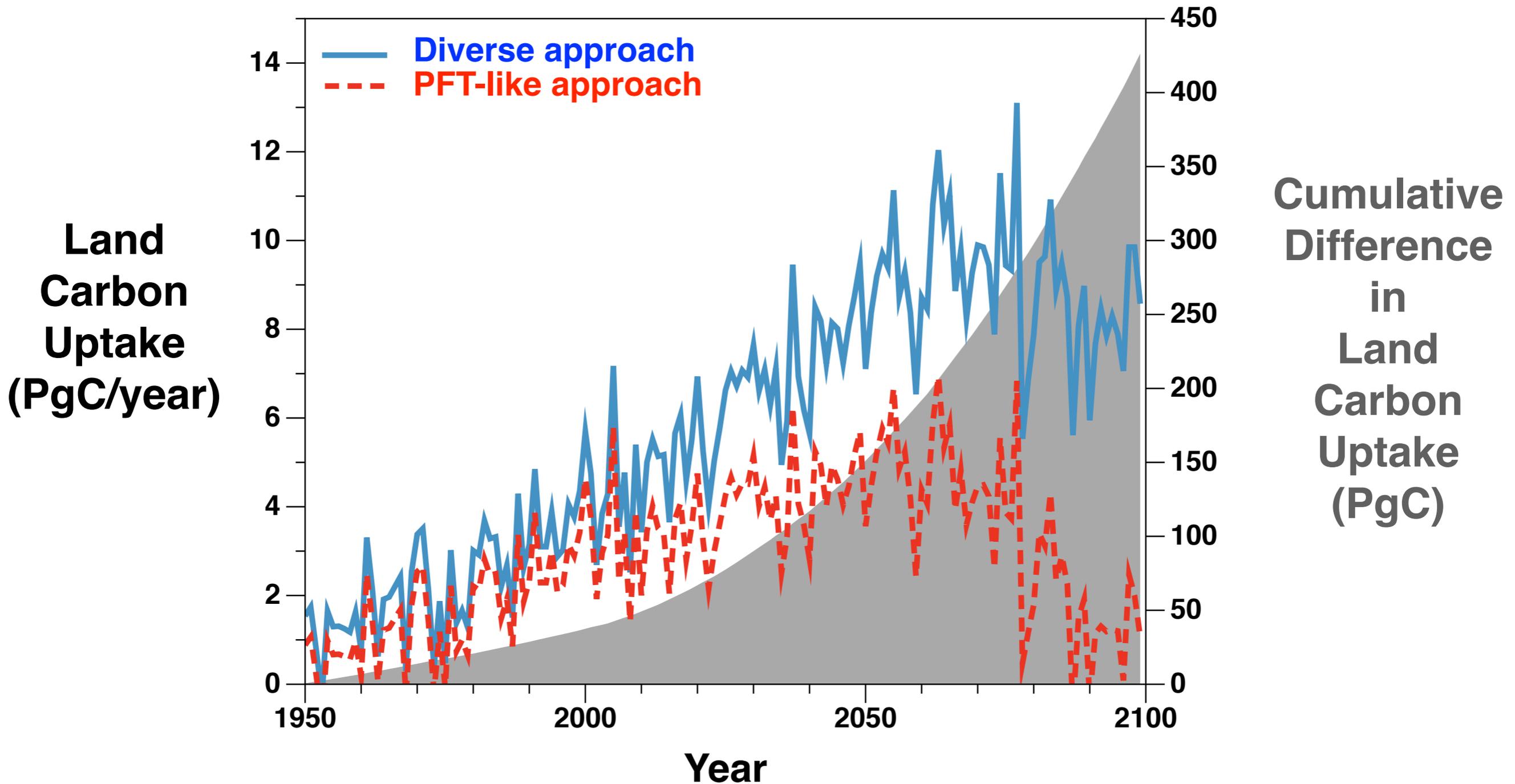
Diverse approach = Greater resilience



Diverse approach = Greater resilience



Large sensitivity >400 PgC

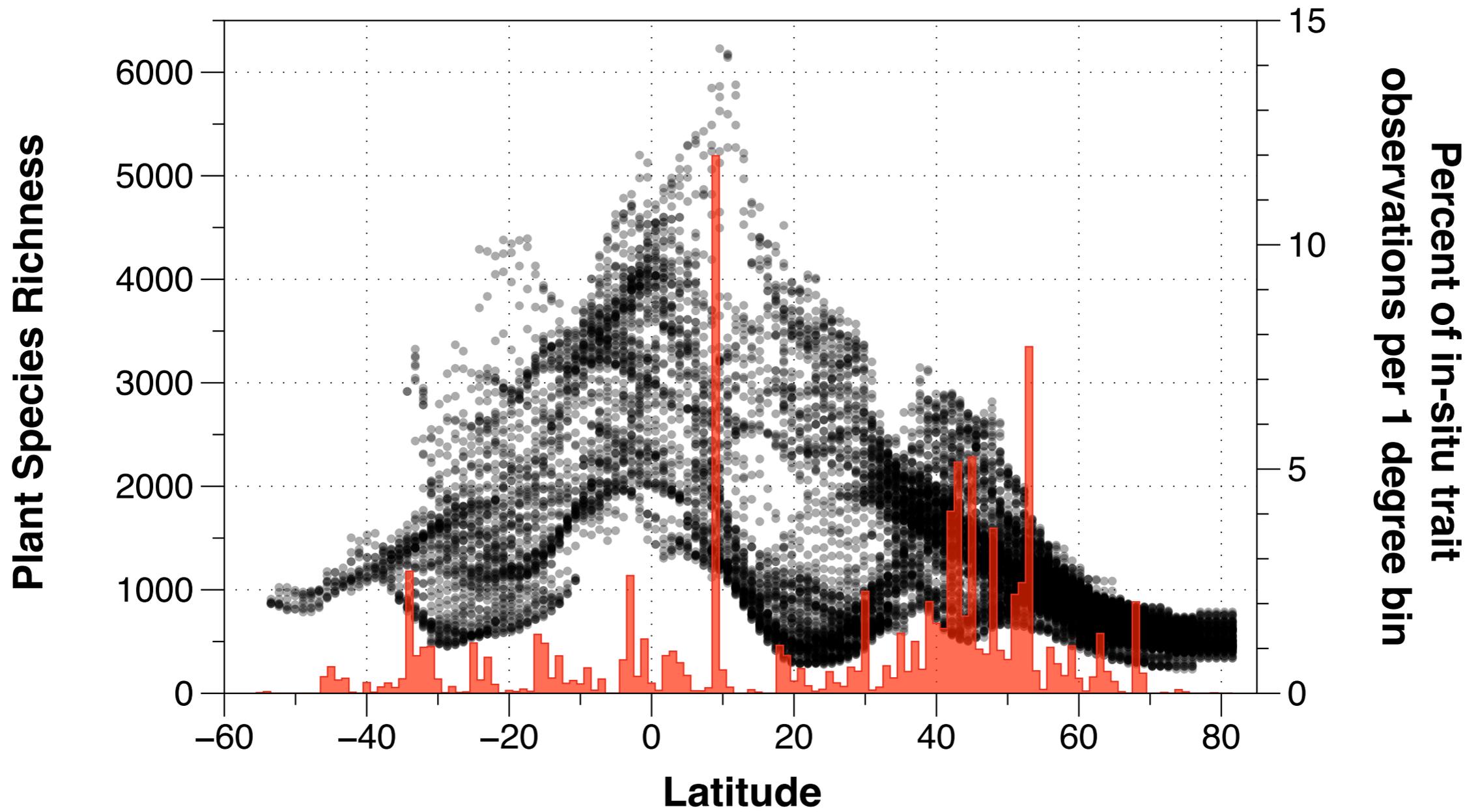


**Earth system models need
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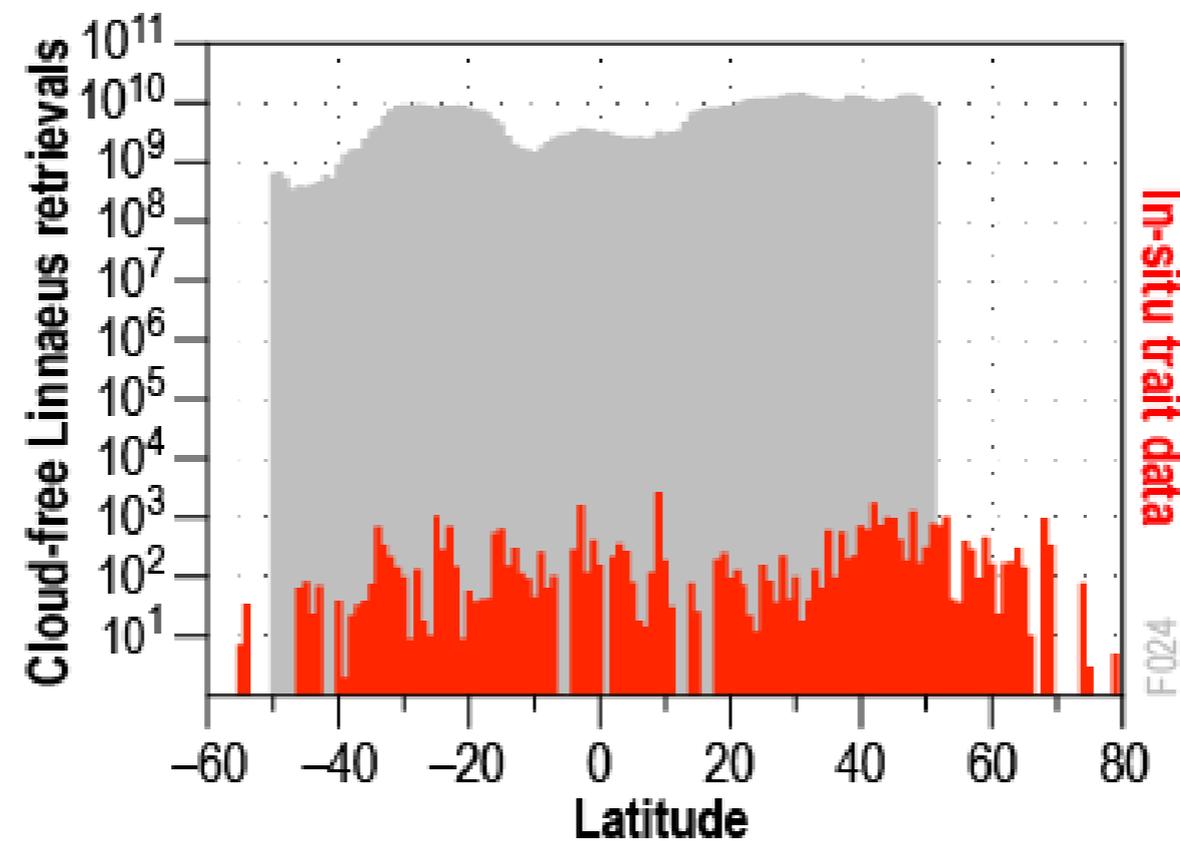
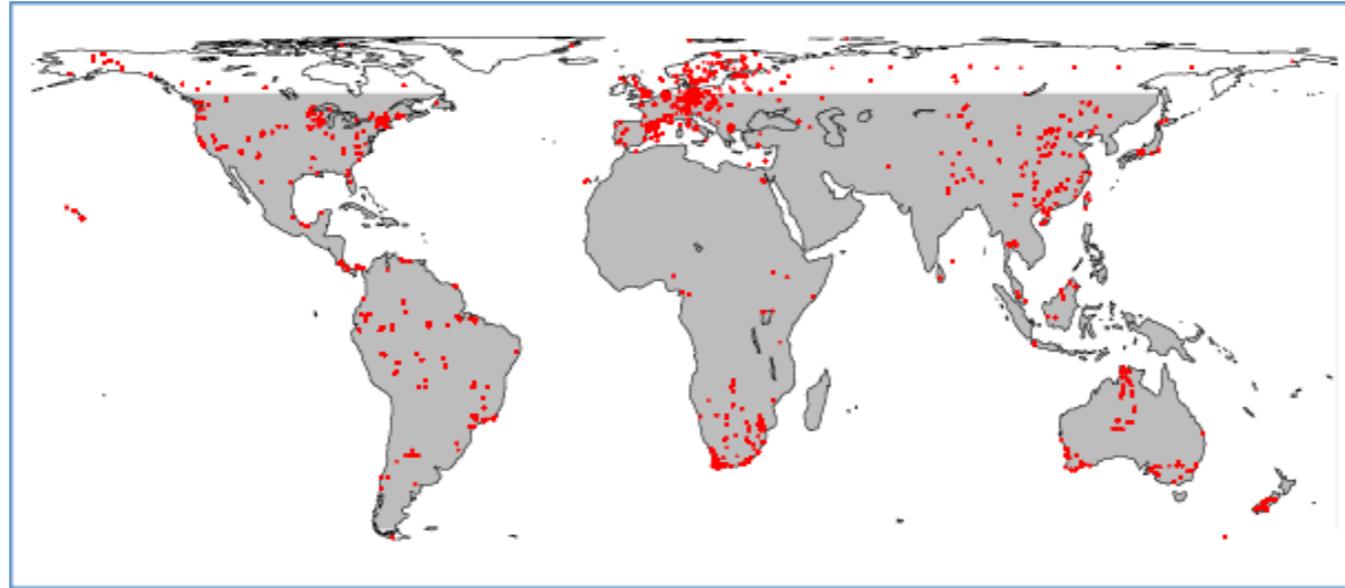
**Ecological theory can get us part
of the way there.**

**Spaceborne imaging spectroscopy
can take us the rest of the way.**

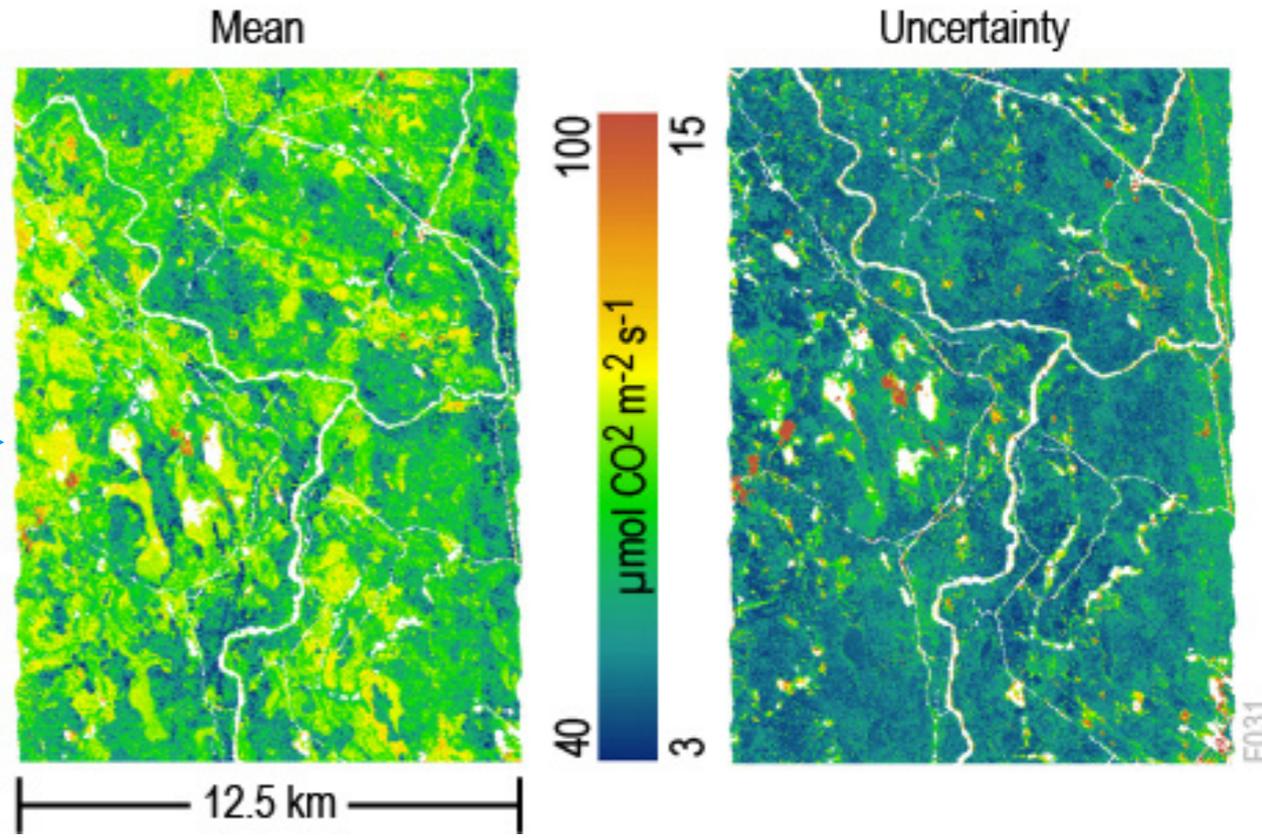
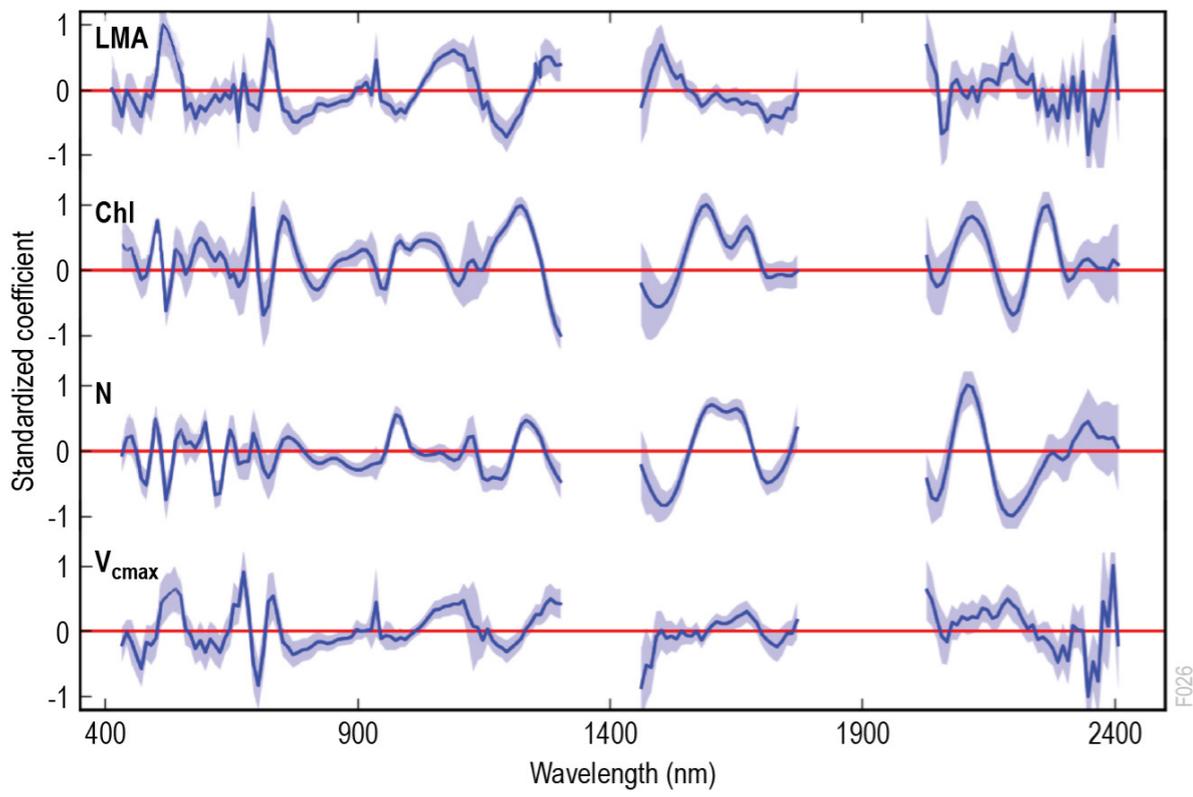
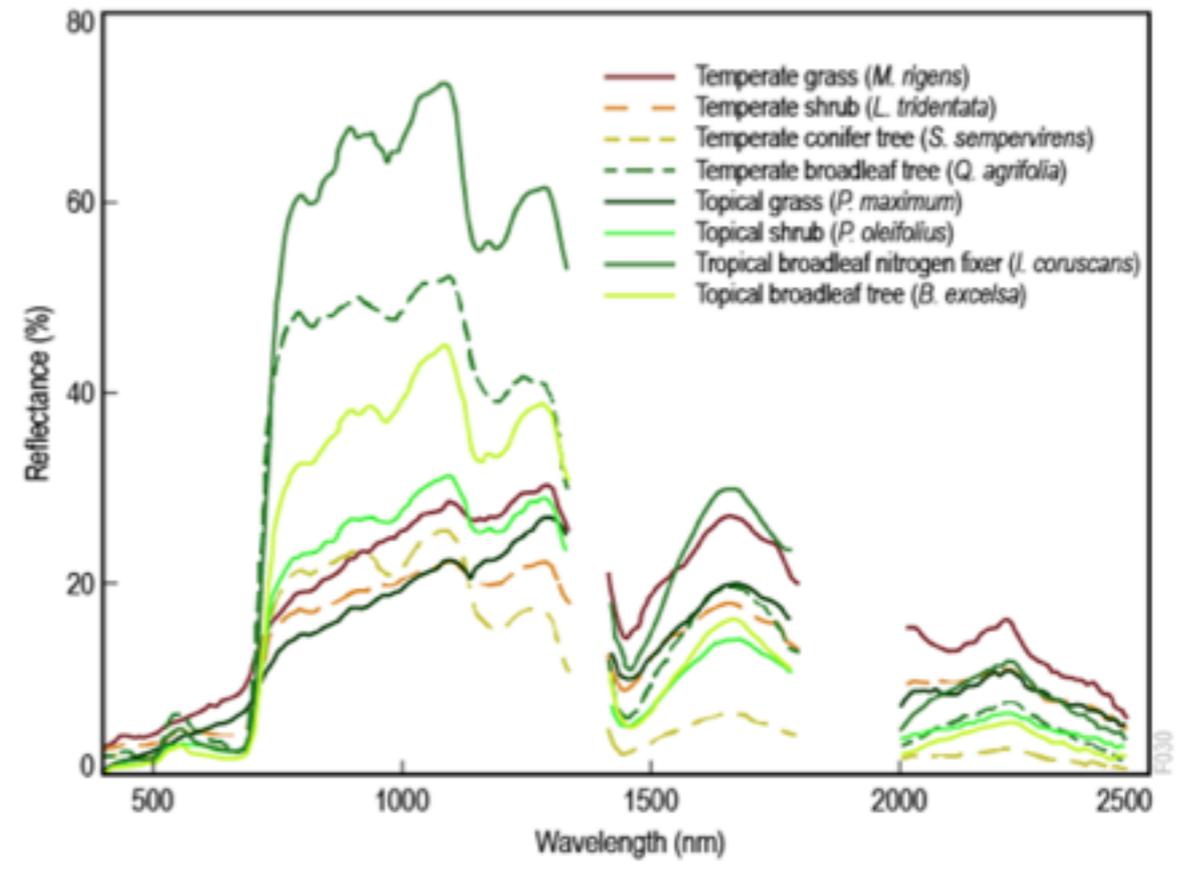
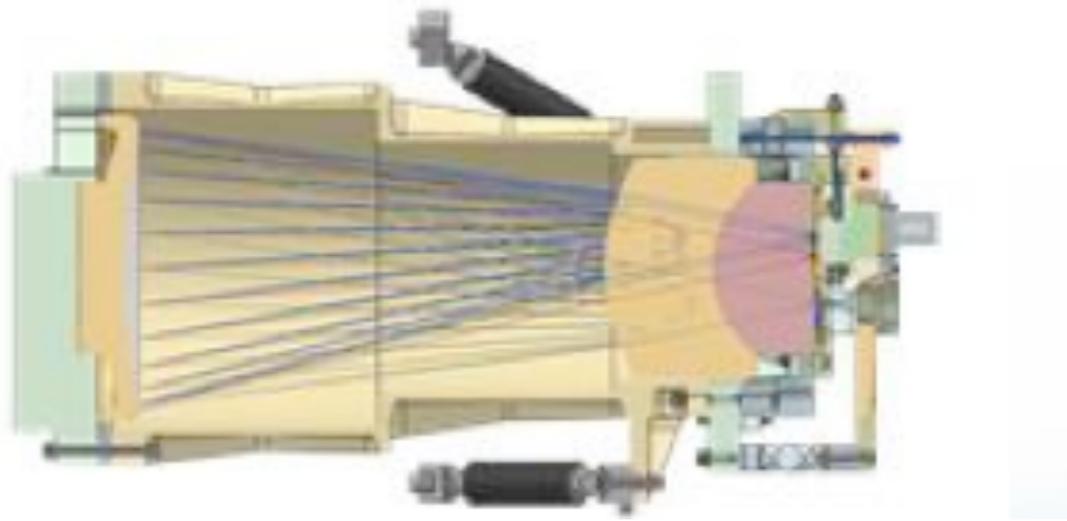
Big data gap



Remote sensing can fill the gap



VSWIR Dyson (380-2510 nm)



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Observing Biodiversity from Space

- NCEAS working group funded by NASA
- First workshop in **December 2014**, second in mid-2015
- Broad group of experts from the biodiversity/macroecology, remote sensing, plant functional trait/ecosystem modelling, and informatics communities



NCEAS

National Center for Ecological Analysis and Synthesis



Observing Biodiversity from Space

- What can we learn about biodiversity and evolution by characterizing global patterns of functional diversity with remote sensing?
- What impact will a comprehensive global data set on functional diversity have on global terrestrial ecosystem models?



NCEAS

National Center for Ecological Analysis and Synthesis



Observing Biodiversity from Space

- Perspective article arguing the urgent need for **truly global biodiversity observations** and the steps needed to integrate that data with existing biodiversity data sources
- Case study using existing airborne imagery across multiple biomes processed in to **L3 data product**
- An outline of a curriculum for a **spectroscopy summer school** for ecologists

Spectroscopy Summer School



Stable Isotope Biogeochemistry & Ecology

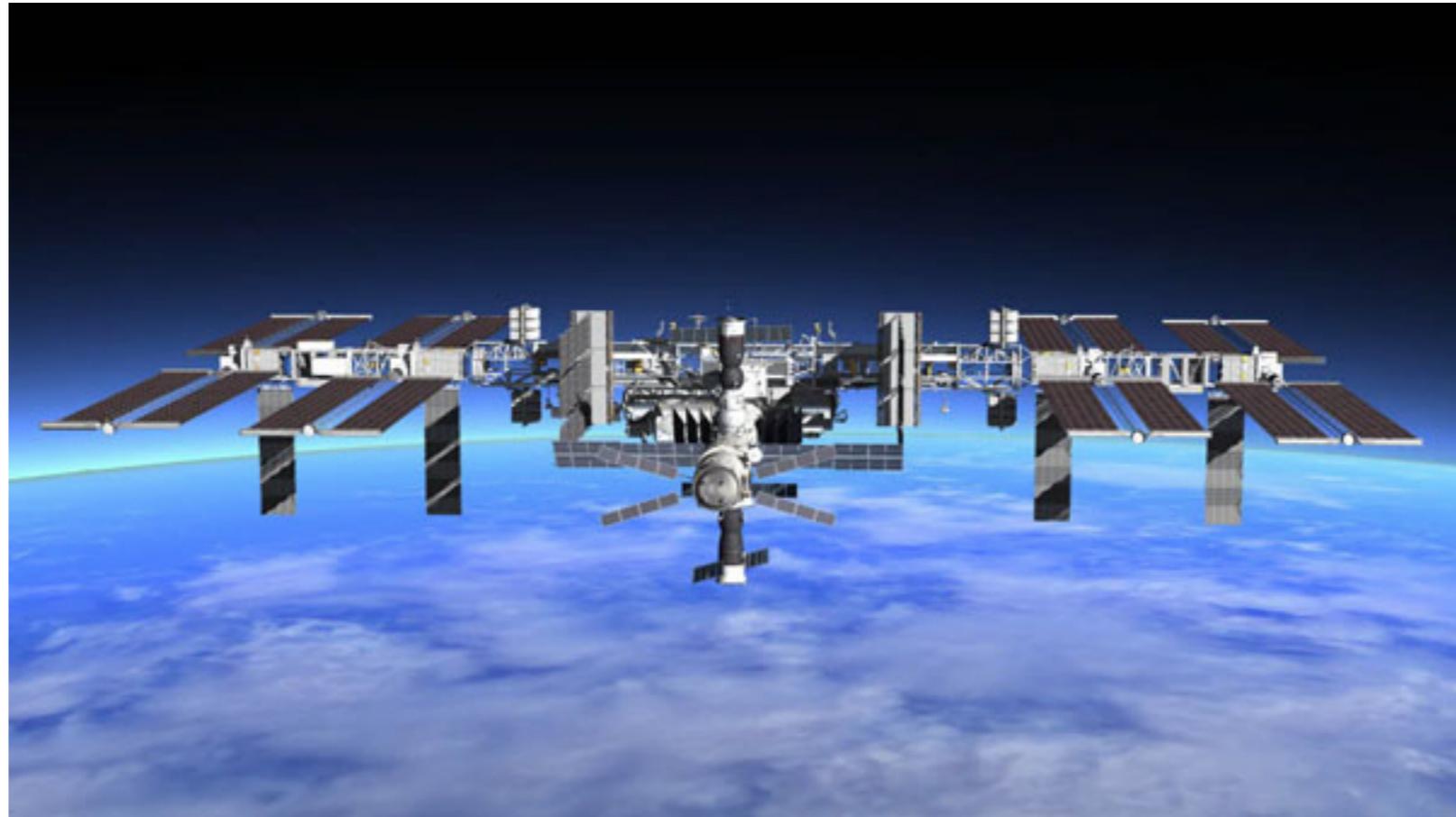
Started 1996, hundreds of alumni across many disciplines



In its eighth year, also highly successful at increasing the pool of scientists trained in flux techniques

The 7th Annual
FLUX COURSE
July 2014

ISS Synergy



OCO-3 -- Fluorescence

ECOSTRESS -- Thermal

GEDI -- Lidar

VSWIR?